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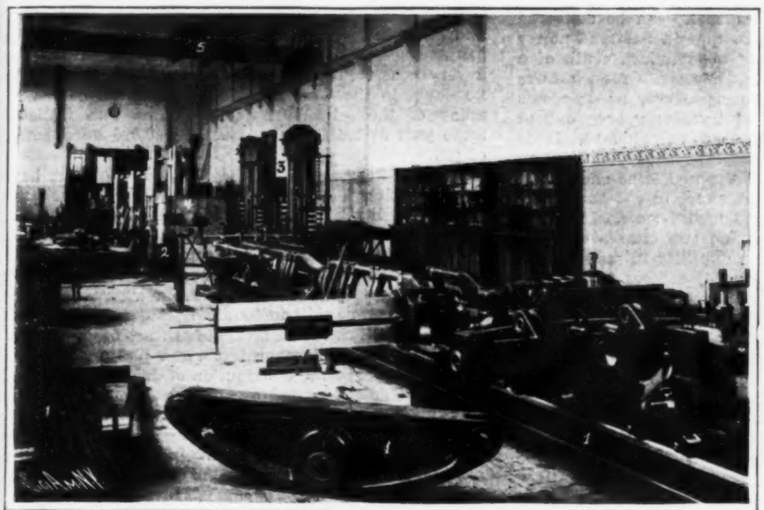


1. Werder machine; 2, Pohlmeyer machines; 3, Martens machines; 4, Borsig machine for testing cylinders; 5, electric traveling crane.

FIG. 1.—TESTING ROOM.

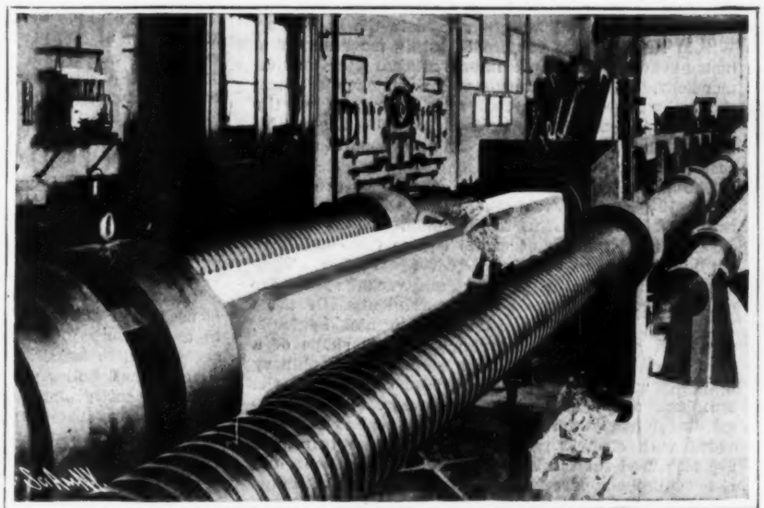


FIG. 2.—500-TON MACHINE FOR TESTING ARMORED CONCRETE PILLARS.

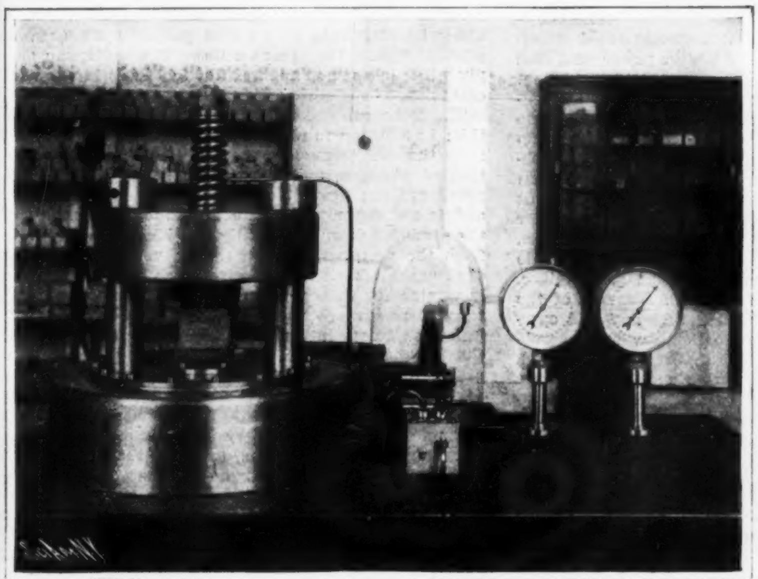


FIG. 3.—40-TON MARTENS COMPRESSION MACHINE FOR TESTING CEMENT.

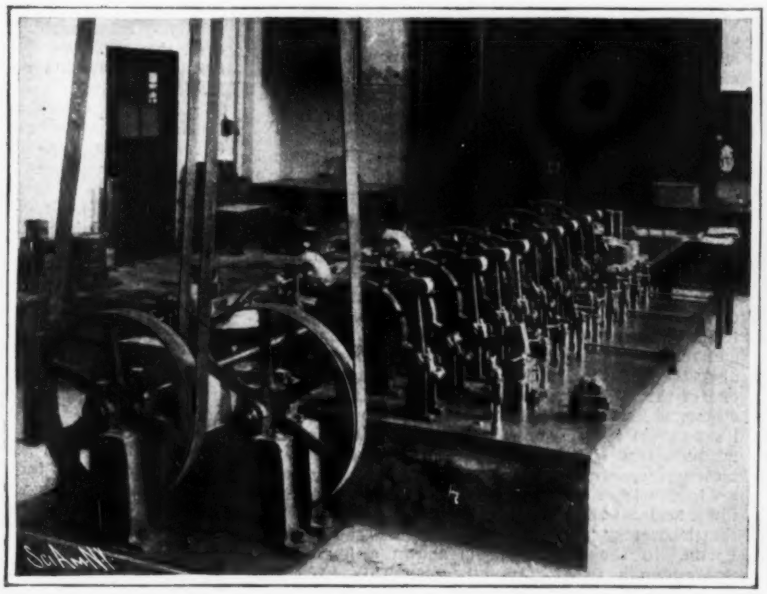


FIG. 4.—BÖHME-MARTENS MACHINE FOR HAMMERING TEST BRIQUETTES.

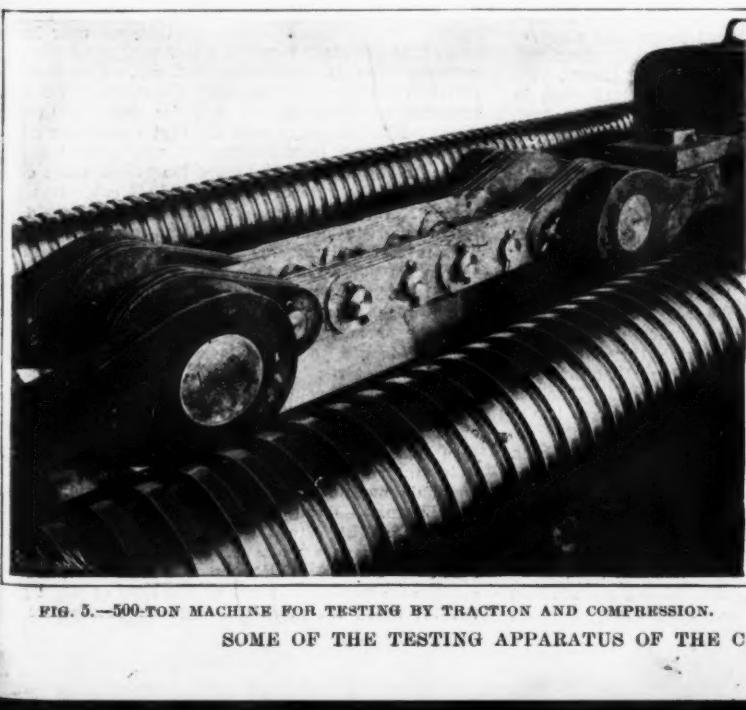


FIG. 5.—500-TON MACHINE FOR TESTING BY TRACTION AND COMPRESSION.

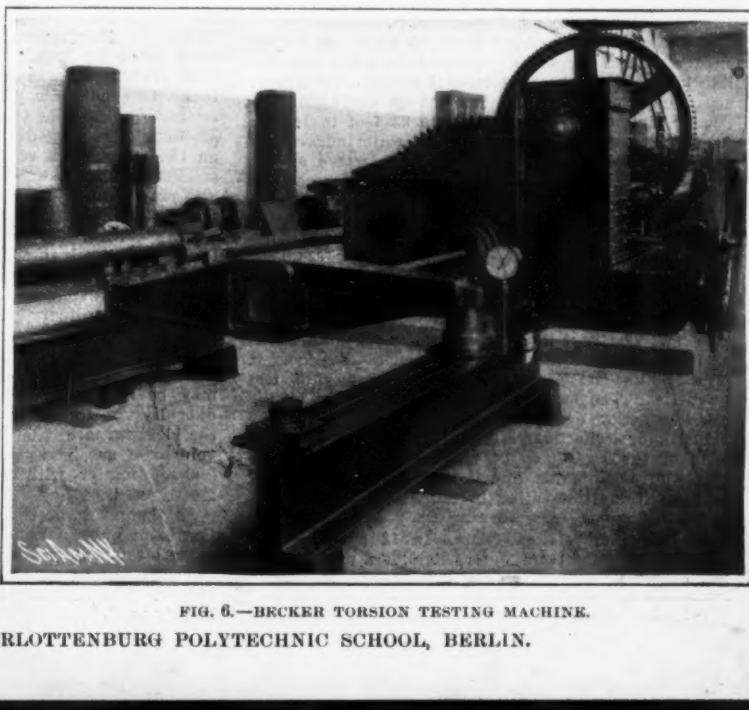


FIG. 6.—BECKER TORSION TESTING MACHINE.

SOME OF THE TESTING APPARATUS OF THE CHARLOTTENBURG POLYTECHNIC SCHOOL, BERLIN.

THE CHARLOTTENBURG POLYTECHNIC SCHOOL'S LABORATORY FOR THE TESTING OF MATERIALS.

By L. Ramakers.

The current issue of the Scientific American contains a detailed article thoroughly illustrated with twelve engravings, on the Charlottenburg Polytechnic School's newly-established laboratory at Berlin, for the testing of materials. While this great technical school has always had a department for the testing of materials, the new institution was established only two years ago, during 1903, when the existing laboratory was moved from Berlin to Gross-Lichterfelde, a suburb, and there combined with the chemical laboratory of the Berlin Academy of Mines. The resulting institution, now known as the "Königliches Material Prüfungsamt," is probably without an equal in the world. It undertakes theoretical and practical experiments of every kind, and conducts investigations on the quality of all materials used in the industries. Within its walls are contained testing machinery and instruments of the most improved character and dimensions. Its laboratory appliances, chemical, mechanical, microscopic, photographic, are all of the latest and most highly-perfected kind. The entire installation, buildings, fixtures, new apparatus, etc., cost $664,000.

The laboratory is located on a plot of ground of about 10½ acres, situated between the railway and the road from Berlin to Potsdam. The buildings cover a total surface of 56,615 square feet, and have a total floor space of about 65,000 square feet. They are all provided with platforms and vacant spaces for conducting open-air tests and experiments. Of these buildings, which are all comfortable and hygienic, the main structures are arranged in the shape of a horseshoe, inclosing two large courts, the machinery buildings and the workshops in the center. All the buildings are connected by tramways. The departments for heavy work are similarly supplied and provided with electric traveling cranes. The tramways are also used for the boiler house, the coal depot, and the weighing apparatus. Below ground the buildings are connected by galleries which contain the steam, water, gas, and electric mains and the drains. The boilers, located in a boiler house on the north side of the grounds, furnish steam to heat the buildings and to drive two 60-horse-power engines. These are connected to two 220-volt continuous-current generators for lighting and power purposes. In addition, the laboratory is supplied with hydraulic power from two mains under a pressure of 200 and 400 atmospheres respectively.

The work of the institution is conducted in six separate divisions. These are: 1, metals; 2, building materials; 3, paper; 4, metallography; 5, general chemistry; and 6, oils. It is impossible to give here a detailed account of the apparatus and methods of each department. The accompanying illustrations supplement the engravings and text of the more complete account in the current number of the Scientific American, to which we refer the reader.

Of the six divisions mentioned, the metal-testing division is easily one of the most important. Among its apparatus for determining tensile, compressive, and torsional strength or resistance, are machines of almost unbelievable power. Fig. 1 is a photograph of one of the halls of this division. It contains, among others, a Borsig machine for testing pipes by applying to them internal or external pressure. The same machine can also be utilized for testing blocks of masonry, concrete, or similar material, by pressure up to 600 tons. Fig. 5 shows the great 500-ton testing machine built by Hoppe in 1891, and installed in this laboratory when the institution was moved from Berlin. In the photograph is shown a huge chain undergoing a tensile strength test. This same machine may also be utilized for compressive tests, as shown in Fig. 2. A large concrete column strengthened by vertical iron rods imbedded in the concrete has been brought to the point of rupture by the terrible pressure of the giant mechanism.

Fig. 6 shows a machine designed according to the Becker system for testing metal bars, rods, and the like by means of heavy torsional strain. The apparatus can exert a twisting moment up to 72,500 foot-pounds, and can take a test piece 33 feet in length. In the photograph a rod is shown while undergoing the test. The registering apparatus is located on the right-hand channel rails at the end of the cross-piece which holds one end of the specimen.

The division for testing building materials is splendidly equipped. Fig. 3 shows a 40-ton hydraulic press built, with others, by the Société de Nuremberg, for testing stone or concrete blocks. The excellent arrangement of the governing, registering, and working parts of the mechanism is apparent from the engraving. The next illustration is of a machine which also comes under the building material division. It is a Böhme-Martens machine for hammering test briquettes. The hammers, which are actuated by the cam-like action of toothed wheels, may be used individually or collectively. This machine is used for tests of the resistance of materials to shocks, prolonged or at intervals, and it has been the means for pursuing some interesting investigations.

To Fasten Labels on Glass.—In 18 parts of cold water, or at most tepid water, dissolve 8 parts of yellow dextrine and 1.50 parts of thymol.—La Nature.

* Specially prepared for the Scientific American Supplement.

A BRITISH OPINION CONCERNING POWER GAS.

Last spring Mr. Dugald Clerk delivered a series of lectures before the Society of Arts in the course of which he gave the following summary of his views concerning various classes of gas for power purposes, which we republish from the Engineering Record.

Many attempts have been made to utilize cheap bituminous fuel for producers, but so far the early commercial stage only has been reached. Commercial success here will come in the near future, owing to the great further reduction in the price of fuel for gas. In the present suction producers, the fuel used is anthracite, and anthracite in London, and wherever there is much carriage, comes to about 24s. a ton. If one could use ordinary engine slack, which can be got at most places at 10s. or 12s. a ton, or even less, one would have a corresponding reduction in the cost of motive power, and instead of coming out at a ninth of a penny, the cost might run down to as low as a twentieth of a penny. Scotch anthracite can be delivered at Glasgow at 15s. per ton, so that in Scotland power may be obtained at a cost of about one-fifteenth of a penny per horse-power hour. Messrs. Crossley have recently produced a bituminous producer which seems to be working fairly well. I have only seen one at work, but it was working very well indeed. It is rather larger and has more plant about it than an anthracite producer, but still the fuel is so cheap that no doubt it is worth a great effort to get something of that kind. Other attempts have been made, and I wish to distinguish between the two classes of those attempts. There is not much difficulty in making producer gas for gas engines from bituminous fuel, if you are content to put up a large scrubbing plant such as is used with the Mond producers, and such as is used in a gas works; but people using steam boilers are accustomed to see a very large generation of power in a very small boiler space, and they do not look upon the large costly plants which are used in some places, although very useful, as solving this particular problem of getting a producer that will work just like a steam boiler with the ordinary fuel. So much for the suction and producer gas generally.

I must now consider shortly the question of blast furnace gas. Mr. Thwaite—I am glad to say an Englishman—demonstrated in 1895 that the so-called waste gas from blast furnaces could be used in gas engines. He built an engine and plant which was very successfully applied at a blast furnace in Britain, only on a relatively small scale. He showed quite clearly, however, that such gas from blast furnaces could be efficiently used for the purpose of motive power, and that it did not want a too expensive course of scrubbing. In England his work was not taken up with any enthusiasm—one does not quite know why; but some German and Belgian engineers took the problem up with great earnestness. The first to attack the problem of using blast furnace gas, after Mr. Thwaite, on a really large scale, was the Cockerill Company, at Seraing, in Belgium. They fitted up a 200-horse-power gas engine, designed by M. Delamare-Deboutteville, who unfortunately died some time ago—a very able engineer, who devoted himself to large gas engines. They further took gas from the blast furnaces of the works at Seraing, and they found that it would operate a 200-horse-power engine practically without scrubbing at all. The gas engineers in Great Britain, and, in fact, all those who had had experience in gas engine work, had always felt that the great difficulty in attempting to work blast furnace gas at all was the difficulty of scrubbing, because a very small amount of grit or tar coming in with the gas spoils an engine. The manager of the works, Mr. Greiner, a very able engineer, became so delighted with this success, and with the absence of scrubbing, that he wrote a very interesting paper, in which he announced that the scrubbing difficulty, and the dust difficulty, was a myth of the imagination of engineers; and he built a very large Cockerill engine, which was exhibited in Paris, and which was called a 1,000-horse-power engine. He got that to work successfully. Then he took orders for a very large installation in another part of Germany, at Differdingen, and when he got his plant to work there he found, unfortunately, that what was true of Seraing was not true of Differdingen. He found that both his pistons and his valves were in serious trouble in a very short time because of dust. He found then that dust in gas depended very largely on the composition of the iron ore which was being smelted. In one district a gas was obtained which was practically free from dust; in another district the gas was laden with a fine silicious dust. There were two difficulties: one was the dust and the other was the tar. For a long time very considerable effort was made on the Continent to get over these difficulties; partly by scrubbing with ordinary scrubbers, such as are used in ordinary gas works, and partly by using a centrifugal separator, whirling round the gas with a great velocity, and a spray of water, they were able to separate out both tar and dust, and that difficulty may be said now to have been removed. Another difficulty was the cooling of the gas: as the gas leaves the blast furnace it is very hot, and to cool that great volume of gas, many cubic feet an hour, would be a difficult matter with water, so that air cooling is mostly used.

As the result of this work, there are now on the Continent quite a number of installations of engines using blast furnace gas. At Hoerde there are two distinct systems in operation—the Deutz and the Oechelhauser. The Koerting and Cockerill engines are also largely used.

For a time English manufacturing engineers fought rather shy of these engines, because the risk seemed too great; but now the subject has been thoroughly taken up, and the engines are being established at a considerable rate in this country. There are three places where they are at work: one is at Messrs. Cochrane's works at Middlesborough, where they have two Cockerill engines, one 500-horse tandem double-acting, which works very well indeed, and another large engine of 600 horse-power, with a single cylinder. Then at Sir Alfred Hickman's, at Wolverhampton, they have several systems at work, including Cockerill, Crossley, and Premier.

Messers. Mather & Platt, of Manchester, too, have taken up the subject, and they have built engines for blast furnace and producer gas—the Koerting 700-horse for blast furnace gas, particularly.

Messrs. Beardmore, in Glasgow, have now running a large Oechelhauser engine driving a rolling mill, and they have arranged a gas plant using bituminous fuel and scrubbing very extensively in order to make the gas fit for use in the gas engine. Altogether there is a very considerable movement at present, and I have no doubt in the very near future we shall have very many of these large engines working and utilizing some part at least of this waste 1,000,000 horse-power of gas.

I do not, however, think that English engineers have been too slow. In England I consider that we have done our full share, both in the theory and practice of the gas engine, although on the Continent, no doubt, they feel the want of the large gas engine more than we do on account of the greater cost of fuel. Now that the attention of English ironmasters has been called to it, they will undoubtedly make the large gas engine help them in the struggle against other nations.

I now come to another important matter, and that is the question of the distribution of gas from a central station. The production of power gas for distribution from a central station has long been a favorite scheme of many engineers. Many years ago the late Sir William Siemens was very much in favor of such a scheme, and he for a long time advocated the establishment of central power gas stations and the distribution of gas for power from central stations—not gas for lighting. A very great and important experimental installation is just on the point of being completed for the South Staffordshire Mond Gas Company. I am informed by the engineer of the station that this great establishment will set to work in about a month, and will distribute cheap fuel gas over an area of something like 120 square miles. The maximum supply with the present plant, although there is room for extension, is something like 15,000 horse-power.

The Mond gas differs from ordinary producer gas in this: in addition to making the gas, the ammonia that is in the coal is saved. Many coals contain a proportion of nitrogen, and if these coals on being decomposed are not heated too highly, ammonia is formed and is not decomposed. To keep the temperature of the producer down sufficiently, the Mond practice is to flush the producer through with a very large volume of steam in addition to the air—much more steam than is wanted for the chemical decomposition. About 2½ tons of steam are used for every ton of fuel. The inflow of steam into the producer has two purposes: the one is that it keeps down the temperature and prevents the ammonia being lost; the other is that it prevents the formation of clinker, and the stopping up of the producer. In this arrangement, to get the ammonia out, it is necessary after scrubbing and getting the tar out of the gas, to scrub the gas in great acid towers, making quite a gas works installation. This does not belong to the type with which I consider the producer should be concerned; that is, the type of producer which takes the place of a steam boiler and does its work with no more complication than the boiler.

To distribute the Mond gas it is necessary to put it under some pressure, because the volume required is so very great. The calorific value is only about one-fourth or one-fifth that of ordinary coal gas. The consequence is that to distribute this gas over large areas it is necessary to put it under very much heavier pressure than is used with coal gas. The installation is therefore provided with a compressing house, intended to compress the gas for delivery in the mains. Mr. Humphrey tells me that a test was made recently at this establishment in which air was delivered along a main five miles long from these compressors at the rate of one and a half cubic feet per hour. If that were pumping gas this rate would be fully equal to about 15,000 horse-power per hour. This rate of delivery was attained with a pressure of 10 pounds per square inch at the central station, so that it is thought that ample pumping plant and ample pipe accommodation have been provided to take the enormous volumes of gas necessary in this system. It will be very interesting indeed when this installation starts. It is one of the largest and most important experiments in progress in the world, and all engineers look with interest upon it, and wish it every possible success.

In carrying on the operations of this great station it is required to pump water and acid to absorb the ammonia and to keep up the general circulation of the system. A large pumping house is, therefore, provided in addition to the other large erections, the whole forming a very important station.

The same trouble which is met with in blast furnace gas is also met with in gas of the type of Mond gas, the tar being the great difficulty. If there were no

tar to deal with, all these matters would be very simple, but in a large installation, such as this South Staffordshire Company's installation, there is no real difficulty, because there is space enough to build up the scrubbers; but if anything of that sort had to be done on board ship, say, it would be a very different matter.

TEA-MAKING MACHINERY.

An interesting report is furnished by Consul Anderson, of Amoy, on the use of machinery in curing tea. The consul says the machine process is not a success, and that it is not regarded with favor in Formosa and other tea-growing districts. The letter follows:

A number of tea-trade journals in the United States and England at the present time are containing accounts of the successful operation of tea-curing machinery at An-Pei-Ching, near Tamsui, Formosa. The accounts are so much alike as to suggest that they have come from the same source. They represent that the operation of the machine-curing plant in Formosa, which was established by the Japanese government late in 1902, is very successful, and intimate that the machine process is likely to soon supersede all others. As a matter of fact the machine process is not a success from a commercial standpoint, and if it should supersede present methods, would likely revolutionize the Oolong tea trade of the world.

The machinery plant was established by the government in Formosa a little less than three years ago, in line with the movement in Japan to produce machine-cured tea for competition with the rapidly growing Indian and Ceylon tea trade, the firing of the latter teas being practically altogether by machinery. The plant was well built and splendidly equipped and is beautifully situated. It was realized at the beginning of the enterprise that the Indian and Ceylon methods would have to be modified considerably before they could be adapted to the Formosan or Chinese tea, and the plant established in Formosa was constructly partly in England and partly in Japan by a Japanese expert who has studied Indian and Ceylon methods, this expert practically constructing a new machine for "withering," "sieving," and "rolling" the leaf. The factory thus established is supposed to have a capacity of 500 pounds of tea per day, or possibly 100,000 pounds of tea per season, working under pressure. Speaking of the results of the establishment of the factory, a tea expert well known in America as one who has long been identified with Formosan and Chinese teas, says:

"So far as I am able to get at the results of the experiments in this connection, as demonstrated in the working of the Formosan government's An-Pei-Ching plant, the 'withering,' 'sieving,' and 'rolling' machine processes are a success with the leaf, while the 'cutting' and 'firing' are considered, at least by Chinese experts, to be unsatisfactory. Firing by 'desiccator' machine is said to be too quick, better results being obtained by the old-style basket firing. It is generally believed here that the government experiments in the machine plant have so far been carried on at a loss."

It is a notable fact, therefore, that the portion of the machine plant which is a success is the portion which was worked over or adapted by the Japanese expert. Practical tea men here are unanimously of the opinion that machine curing will not become general in Formosa, at least with labor at its present price and with no greater success on the part of the machine plants than has so far been attained. There are a number of reasons why machine curing will not be rapidly introduced, other things being equal, and these reasons will appeal to the trade in the United States.

The bulk of the Formosan Oolong tea trade is with the United States. It consists of a number of certain well-known chops or brands prepared by certain well-known processes and representing certain qualities. The tea men of the United States have built up trade in these respective grades, and a variation from these would probably have very disastrous results to that trade. It has been the custom of the American houses to buy their tea from year to year of Amoy or Formosan houses, chiefly the former, and they have come to rely upon them for their particular brands or grades to supply their own particular trade. The "good will" of the business of these Amoy tea houses has come to be very valuable, and the unity of interests between the American tea seller and the commission houses here which do the buying for the American sellers is strong. It is easy to appreciate the fact that unless the machine-cured tea is practically the same as the several chops or brands to which the American consumer, who takes nine-tenths of the Formosan crop, is accustomed, the trade will be interfered with directly and vitally.

The machine-made tea is not the same as the other brands, and it is likely that it would not be a success for that reason if for no other. The machine-curing plant has been interesting as an experiment, but it is hardly probable that the tea business of Formosa will be revolutionized at this time, when the island's best customer is not willing to have it revolutionized. So long as the grades and chops now in use can be produced as cheaply as the machine-made tea, there is no reason why American tea men or their representatives here should turn to the machine-made product. The firing and curing processes of expert Chinese workmen—processes worked out after centuries of experiment, trial, study, and practical experience—can best deal with varying leaf and changing conditions in the crops. Delicate flavors are not always conserved best by machinery.

So far this season the Formosan tea crop is fairly good. It is moving to the United States with unusual promptitude, 1,205,521 pounds having been shipped out of Amoy for the United States previous to June 15. The weather at present is also favorable to good crops later in the season.

THE USE OF BOILER COMPOUNDS.*

By William M. Booth.

There are three chemicals which are known, even by unscientific men, to attack boiler scale. These are caustic soda, soda ash, and tannic acid compounds, the last being derived from sumac, catechu, and the exhausted bark liquor from tanneries.

Caustic soda in large excess is injurious to boiler fittings, gaskets, valves, etc. That it is injurious, in reasonable excess, to the boiler tubes themselves, I have yet to prove. Foaming and priming may be caused through excess of caustic soda or soda ash, as is well known by every practical engineer. I can strenuously condemn tannic acid, and of the use of its salts, I am fearful. It may unite with the organic matter, present in the form of albuminoids, and with calcium and magnesium carbonates. That it removes scale is an assured fact; that it removes iron with the scale is also assured, as tannic acid corrodes an iron surface rapidly.

Compounds of vegetable origin are widely advertised, but they often contain dextrine and gum, both of which are dangerous, as they coat the tubes with a compact scale, not permitting the water to reach the iron. Molasses is acid and should not be used in the boiler. Starch substances generally should be avoided. I have not investigated the action of kerosene, but in large quantity its use must be dangerous, as it is very volatile and must soon leave the boiler and pass over and through the engine.

There are two materials, the use of which in boilers is not prohibited through action upon the metal itself or on account of price. These are soda ash and caustic soda. Sodium triphosphate and sodium fluoride have both been used with success, but their cost is several hundred per cent greater than soda ash. If prescribed as per analysis, in slight excess, there should be no injurious results through the use of caustic soda and soda ash. It would be practicable to manufacture an intimate mixture of caustic soda and carbonate of soda, containing enough of each to soften the average water of a given district.

There is a great deal of fraud in connection with boiler compounds generally. The better class of venders advertise to prepare a special compound for special water. This is expensive, save on a large scale, in reference to a particular water, for it would mean a score or more of tanks with men to make up the mixtures. The less honest of the boiler-compound guild consign each sample of water to the sewer and send the regular goods. Others have a stock analysis, which is sent to customers of a given locality, whether it contains iron, lime, or magnesium sulphates or carbonates.

Any expense for softening water in excess of 3 cents per 1,000 gallons is for the privilege of using a ready-made softener. Every superintendent in charge of a plant should insist that the compound used be pronounced by competent authority free from injurious materials, and that it be adapted to the water in use.

Boiler compounds should contain only such ingredients as will neutralize the scale-forming salts present. They should be used only by prescription, so many gallons per 1,000 gallons of feed water. A properly proportioned mixture of soda ought to answer the demands of all plants depending upon that method of softening water in limestone and shale regions.

The honest boiler compounds are, however, useful for small isolated plants, because of the simplicity of their action. For plants of from 75 to 150 horse-power two 24-hour settling tanks will answer the purpose of a softening system. Each of these, capable of holding a day's supply, provided with a soda tank in common, and with sludge valves, has paddles for stirring the contents. Large plants are operated on this principle, serving boilers of many thousand horse-power. Such a system has an advantage over a continuous system, in that the exact amount of chemical solutions required for softening the particular water can be applied. For some variations of such a system, several companies have secured patents. The fundamental principles, however, have been used for many years and are not patentable.

CAN A STEAM TURBINE BE STARTED QUICKER THAN A RECIPROCATING ENGINE?†

By A. S. Mann.

If a large steam turbine is cold and at rest, how quickly can it be started? Can it be brought up to speed as readily as can a good cross-compound engine that is cold all over? Most station men would have doubts as to the adaptability of the large turbine, say 1,500 kilowatts, or 2,250 horse-power, for emergency work. The possibilities of an engine with a 62-inch low-pressure cylinder in starting practically cold and coming up to synchronous speed are well understood. A station manager would criticise an engineer who would open his throttle as fast as he dared without wrecking his piping system and let his machine jump into her work. Most engineers would consider ten minutes as rather a fast start, and fifteen minutes as a more usual starting period, including time taken for warming up.

The station at present under consideration is equipped with three Curtis turbine-driven alternators, 40 cycles, 10,000 volts, each of 1,500 kilowatts, normal capacity. During the summer months the station is operated as an auxiliary to a water-power plant, taking all sudden overloads. A signal has been arranged, a ¾-inch whistle, so that it can be blown instantly should the power fail.

The boiler room has steam up at all times, supplying a system for manufacturing purposes other than power, and slow fires are kept in enough boilers to make steam needed for the normal load.

At the sound of the whistle the water-tender starts a blower on the extra row of boilers; all blast dampers are opened up and all stokers are allowed to feed at the maximum rate. Each fireman dumps his free ash and bars over his red fire. The man in charge of the coal and ash conveyor starts the pressure pump for step bearings. One of the turbine men starts the exciter which supplies current to the auxiliaries beside its field current; a second turbine man starts the circulating pump and then his turbine. The hot-well pump and the air pump are started by the oiler. These movements take place simultaneously. The force is organized upon the lines that obtain in a fire station—each man has his specific duty, and after performing it looks to see if there is nothing more for him to do. Only a few seconds elapse between starting the first pump and starting the first turbine. The turbine throttle is opened as fast as an 8-inch steam valve can be opened without endangering the steam piping system. It is not considered advisable to open the throttle valve as fast as a man's strength will permit; but if nothing unusual occurs in the pipe line, sentiment does not spare the turbine. One electrician attends to the switchboard and telephone. As soon as the machine approaches speed, the synchronizing system is cut in and the main switches are got ready. One and one-half minutes will do the work here outlined, including the time taken in mustering the crew.

Manipulating an engine regulator so that it shall be at a precise speed and at an exact phase relationship from some other machine, not more than 1/1500 part of a second removed from it, is no matter that can be hurried, and one minute is fast time on such work. But the whole thing, phasing-in and all, has been done in two and one-half minutes, including full load on the turbine, which started from a standstill. This performance has been gone through a great many times, and our record book shows that, out of forty-three such calls, ten starts were made in two and one-half minutes, eighteen in three minutes, and fifteen in three and one-half minutes.

The two quickest starts have been made in forty-five seconds and seventy seconds respectively, including phasing-in. These two quickest starts were made on a turbine which had stood for twenty-four hours with the throttle valve shut tight, though there was a slight leakage past the seat. After the throttle valve is off its seat, it is not more than thirty seconds before the turbine is up to speed. A cross-compound reciprocating engine of the four-valve type, 2,250-horse-power capacity, can be brought up to speed from a standstill in five minutes if it is hot all over. This five minutes is to be compared with the seventy seconds required for the similar turbine operation.

A reciprocating engine which is turning over slowly with the throttle valve just off its seat or with by-pass open and having all its oil cups open and regulated can be brought up to speed, say seventy-five turns, in two and one-half minutes. This can be compared with the thirty seconds necessary for bringing the turbine up under the same conditions—that is, about one-fifth the time necessary for bringing up the engine. If the engine is cold all over and has all its oil cups shut tight, all its auxiliaries quiet, fifteen minutes is called a rapid start. Starts have been made under such conditions in twelve minutes. When we start a cold turbine, we open up the valve and let her turn, and in two minutes we are ready to bring her up to speed, and she will be at speed in two and one-half minutes, dividing the engine's time by more than four.

ECONOMIES OF MECHANICAL DRAFT.

Concerning mechanical draft the following statements are made in Chemical Technology by Mills and Rowan:

"The principles of what is now becoming well known under the name of 'forced combustion' have been repeatedly advocated during past years by those who have devoted thought and study to the subject. The position assumed by them—which is now finding favor among engineers—has been, in brief, that the air supply required for combustion in furnaces can be more economically furnished by mechanical power than by the action of chimneys and that the mechanical method has other advantages which enable it to be preferred to the one which is older, but more imperfect. One of these advantages is the higher temperature of combustion, which is equivalent, with a boiler of good design, to an increased evaporative power of the boiler or to increased evaporative effect for the fuel. Another advantage, which has not been fully realized in any plan as yet introduced in practical work, is that the rate of travel and escape of flame and hot products of combustion is under control. It is thus possible to cool them more completely than can be done when chimney

* Abstract of an article in The Chemical Engineer, April, 1905.

† Abstract of paper presented at the Scranton meeting (June, 1905) of the American Society of Mechanical Engineers.

draft is used, and this means a saving of heat which would otherwise be uselessly dissipated. Mechanical or artificial draft thus presents to us a method of economically furnishing the air supply to furnaces and producing a more efficient combustion temperature, while it also renders possible further economies due to retarding the movement and escape of hot gases and to preliminary heating of the air supply by waste heat or otherwise."

PREPARATION AND COMPRESSION OF PURE GASES FOR EXPERIMENTAL WORK.*

By R. S. HUTTON and J. E. PETAVEL.

INTRODUCTION.—Having been engaged for some time past on experimental research dealing with the effect

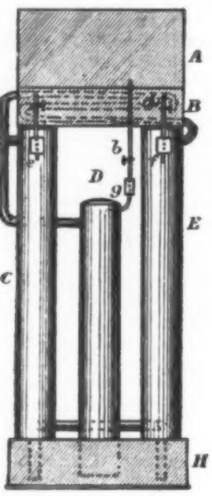


FIG. 1.—HYDROGEN GENERATOR PLANT.

(Scale, ½ inch to foot.)

A, acid reservoir; B, cooling tank; D, generator proper; C and E, washing towers; *b*, valve regulating admission of acid; *g*, sight feed for ditto; K, outlet for gas; *c* and *d*, valves regulating water admission to washing towers; *e* and *f*, sight feeds for ditto; H, cast-iron tank acting as seal to the cylinders and into which spent acid flows; K, outlet for gas.

of high gaseous pressures upon electric furnace reactions, the necessity arose of preparing, compressing, and storing several gases which were either not available commercially, or which could not thus be obtained in the desired state of purity. Although a very great deal of information had been published relating to the production of the various gases in sufficient quantities for ordinary laboratory experiments, such methods cannot be easily applied when the required scale of working is considerably larger. On the other hand, the commercial manufacture in some cases has been most carefully worked out, but the plant required is too large and costly to be practical for temporary use. The object of the present paper is to describe how, with little more than such apparatus as should be available in any chemical laboratory, the preparation of a number of gases can be carried out at a trifling cost and with due consideration as to their purity. It will be noticed that the equipment is so devised as to be available for use in the different cases with but little modification. Those

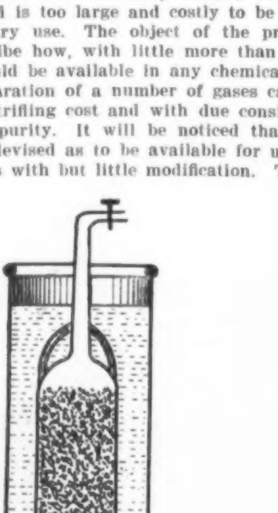


FIG. 2.—EXPERIMENTAL HYDROGEN GENERATOR.

Constructed throughout of lead. Height, 2 feet 6 inches; diameter, 1 foot.

who look for any novelty in the principles of the methods adopted will, we fear, be disappointed; we venture, however, to think that to the increasing number of workers, who either for commercial or scientific purposes require, like ourselves, pure gases in considerable quantities, the information which we offer will be of some value. The apparatus has been devised for gas generation and purification at a rate of about 1 liter per second (130 cubic feet per hour). Hydrogen, nitrogen, carbon monoxide, and ethylene are dealt with in detail. Apart from the information which we have been able to obtain by direct experiment, references are given to several of the more important published accounts dealing with the manufacture on the full commercial scale. For some chemical purposes, the gases would be passed straight from the generator for use in the chemical process for which they were required; on the other hand, it is frequently necessary for convenience to store the gas for subsequent use; in fact, where the experiments are at all general in character, it is advisable to have a stock of different gases constantly available. This involves the erection of compressing and storing plant even where high pressure *per se* does not play a part in the work. Our account, therefore, includes a description of a small plant which we have found satisfactory for these purposes.

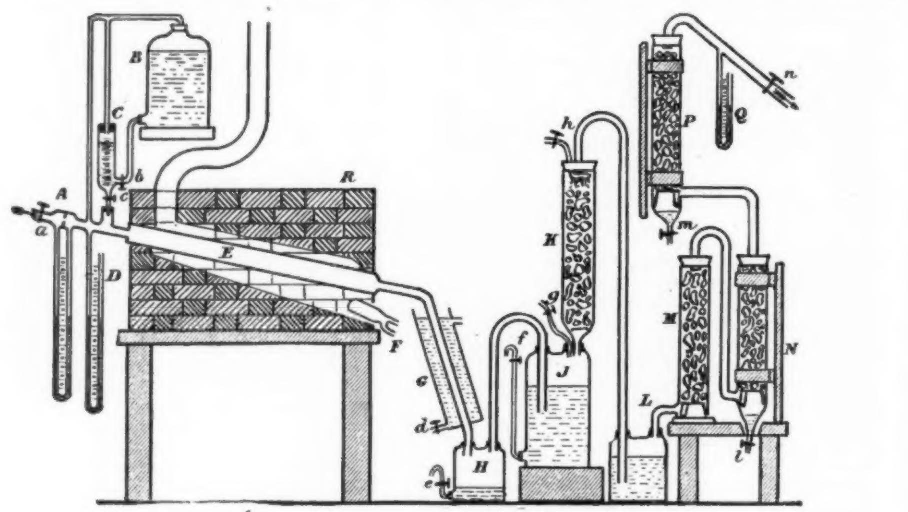


FIG. 3.—DIAGRAM OF NITROGEN PLANT.

a, Air-inlet tap from blower; A, gage indicating rate of flow of air; B, reservoir of ammonia liquor; C, graduated tube for measuring rate of flow of ammonia; *b*, tap for filling tube C with ammonia; *c*, tap for regulating admission of ammonia; E, iron gas-pipe filled with copper turnings; R, furnace; built up of loose firebricks, and heated with large Fletcher furnace tuyere F; G, condenser with water-inlet cock *d*; H, condensed ammonia receiver with draw-off *e*; J, water washer, through which water or acid could be passed, inlet cocks at *g* or *h*, outlet at *f*; L, acid washer; M, quartz tower scrubber; N and P, two caustic soda towers with draw-off cocks at *l* and *m*; Q, manometer; *n*, exit to gasometer and compressor.

Hydrogen: Commercial Manufacture and Applications.—Hydrogen is at present principally employed for inflating military balloons, autogenous welding, and lead-burning (Zeits. f. Elektrochem., 1895, 2, 204), and is manufactured in considerable quantities for these purposes. The older and purely chemical methods of generation based on the action of acids or steam on metals are being to a large extent displaced, where a continuous supply is required, by electrolytic processes, the working cost of the latter being considerably lower. Suitable electrolytic cells can now be installed at a reasonable expense. The plant for the chemical manufacture by the action of acids on metals is of two principal types. The first, a development of the ordinary laboratory "Kipp," will be described later. The second type is designed to give for a limited time a very large quantity of gas, and in principle consists in employing a tall cylindrical receiver filled with metal turnings or granulated metal, the outflow of gas being regulated by the amount of acid which is allowed to flow into the top of the cylinder, the spent acid being run off at the bottom. This latter method is of the two by far the more important for large-scale working, such as for inflating balloons. In this case some 10,000 cubic feet of gas may be required to fill a single balloon, an operation which has to be effected within a short space of time. The process has also been employed for many years at the Royal Institution for the manufacture of hydrogen in connection with the liquefaction experiments, and at a more recent date by Morris W. Travers at University College, London (Phil. Mag., 1901, [6], 1, 411). A plant on these lines has been recently constructed by Messrs. Lennox, Benton & Reynolds, Ltd., capable of delivering some 800 cubic feet of hydrogen per hour. The receiver is a copper cylinder about 6 feet high and 1 foot diameter, and contains a charge of 4 hundredweights of granulated zinc. As will be seen by the diagram, Fig. 1, the actual generator is mounted in the center between two washing towers, each 8 feet high. The three cylindrical towers, which are open at the bottom, are supported in a cast-iron tank, which forms a water seal and collects the spent acid. The towers are surmounted by two superimposed tanks, the lower one containing a lead coil immersed in water to act as cooling chamber, the upper one, lead-lined, acting as acid reservoir. A spray of water keeps the flints in the two washing towers moist. The rate of flow of the acid is observed through a sight feed. An apparatus of a similar type, the design of Ch. Renard, has been adopted by the French army for field use. The employment of zinc has, however, the serious disadvantage that the gas often contains sufficient arsenic to be dangerous if dealt with in any quantity.* Moreover, the gas generated by the action

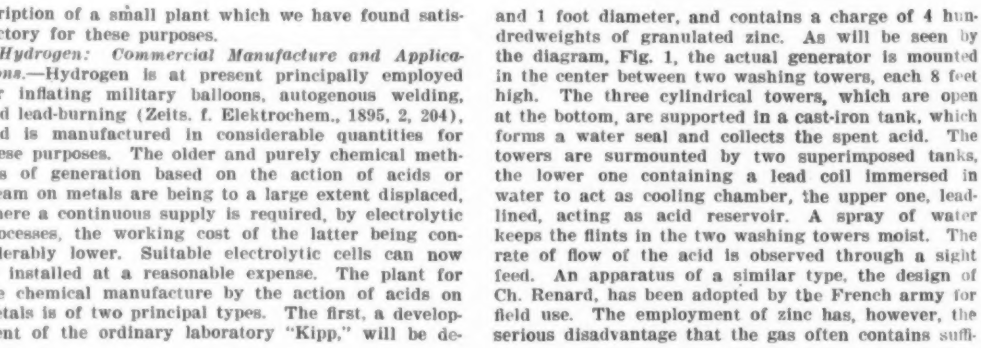


FIG. 3A.—NITROGEN PLANT.

* From the Journal of the Society of Chemical Industry.

*Numerous attempts have been made to remove the arsenic from the gas, among which passage through a heated tube or a solution of a permanganate should be mentioned. Recently Ch. Renard has carried out some experiments on the use of liquid air for condensing the arseniuretted hydrogen in connection with the aeronautical department of the French

of acids on ordinary spelter or metallic iron is liable to be considerably more dense than pure hydrogen. (W. Dürer, Zeits. f. Elektrochem., 1901, 8, 3.) Of other chemical processes, the heating of zinc-dust and soda-lime briquettes is employed in the German army in a portable equipment for balloon inflation, while the reaction between heated iron and steam has recently been applied by the Industrial Engineering Company, who regenerate the iron with producer-gas,

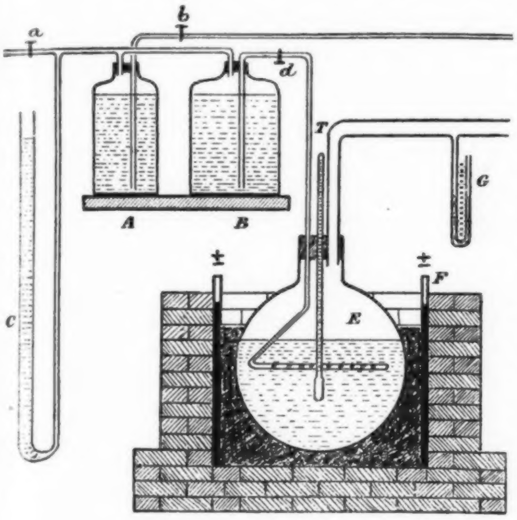


FIG. 4.—DIAGRAM OF CARBON MONOXIDE PLANT.

E, bolt head containing boiling H_2SO_4; T, thermometer; B, reservoir for formic acid; *d*, cock for regulating supply from B; G, gage on main gas-pipe before washing apparatus; F, electric heating furnace; *a*, inlet cock from compressed air; C, tube acting as constant pressure valve, keeping a pressure equal to 2 or 3 feet of water on upper surface of liquids in flasks A and B; A, reservoir of caustic soda solution connected with washing tower K (Fig. 3); *b*, regulating cock for same.

and have thus brought this method into a convenient and practical form. The electrolytic manufacture of hydrogen is coming much to the front; in this case, whereas the first cost is relatively high, the working expenses, whenever the plant can be run continuously, are generally lower than for the chemical method. Numerous types of plant have been designed, the principal requirements being a low working voltage and the effectual separation of the hydrogen and oxygen; the latter, particularly where the gases have to be compressed, being of the utmost importance from the point of view of safety. The electrolytic methods will be found described in monographs by Victor Engelhardt and P. Schoop [V. Engelhardt, Die Elektrolyse des Wassers (Halle: W. Knapp, 1902); P. Schoop, Die Industrielle Elektrolyse des Wassers (Stuttgart: F. Enke, 1901)]; suffice it to say that in principle they can be grouped under three types:

(1) The Schmidt and Ch. Renard systems employ iron electrodes in alkaline solutions, the electrodes being separated by diaphragms of asbestos.

(2) The Schoop system, in which each cylindrical electrode is surrounded by tubular diaphragms, has the advantage of absolute safety from any danger of admixture of the gases, but involves some loss of power through additional resistance. In this case lead electrodes are employed in an acid electrolyte.

(3) The Garuti, Siemens Brothers, and Schuckert

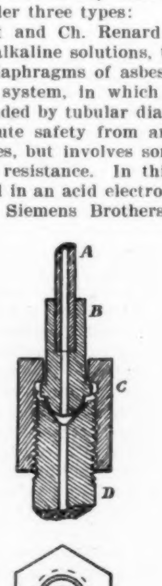


FIG. 5.—CONE CONNECTIONS.

A, flexible copper tubing; B, cone; C, nut by which cone is pressed home: screwed "½-inch gas"; D, standard connection forming part of cylinders, valves, or compressor.

plants employ metallic diaphragms and generally work with alkaline electrolytes.

At the present time almost all the European military authorities have adopted one or other of these electrolytic plants for balloon purposes, but in Germany the government makes use largely of the waste hydrogen evolved in the electrolytic alkali industry, an example which will, no doubt, be widely followed in the future, when it is considered that, even at a moderate estimate, some 240,000 cubic feet of hydrogen are going to waste daily in this way (cf. Zeits. f. Elektrochem., 1895, 2, 290). At least three large installations (Buffa, Bull. de l'Assoc. des Ing. Electr. [Liége], 1900, 11, 305), those at Brussels, Lucerne, and Rome, exist on the Continent for putting on the market compressed hydrogen obtained by the Garuti process, a notable economy resulting from the fact that the oxygen, which is also compressed, finds a still more ready sale. A complete consideration of the question of cost would carry us too far, but full details will be found in the monographs referred to. Suffice it to say that, with spelter at £21 a ton, a cost of at least some 35s. is incurred in zinc alone per 1,000 cubic feet of hydrogen obtained, whereas by several of the electrolytic processes the same amount of hydrogen can be obtained for 157 kilowatt hours, which, even at 1d. per unit, a high estimate for power generation when used continuously, only amounts to 13s. 1d. It should be borne in mind that the oxygen produced simultaneously is also of considerable commercial value. Thus where an uninterrupted supply of gas is required throughout the entire year, the electrolytic methods offer considerable advantages. Owing, however, to the much smaller capital outlay, the older chemical process is preferable when the hydrogen is required occasionally only, but in large quantities. Several years ago Dewar showed, as a lecture experiment, how coal-gas could be freed from methane and other hydrocarbons by cooling it to a sufficiently low temperature. Recently d'Arsonval (Ann. Chim. et Phys., 1902, [7], 26, 446) has proposed this as a method of obtaining hydrogen; the process has, however, not yet proved of any commercial value.

Experimental Plant.—In considering the type of apparatus suitable for experimental work, it must be borne in mind that the plant should be capable of producing gas at a comparatively high rate, at least for a limited number of hours. As will be more fully explained in describing the compressing plant, it is advisable to make the gas in sufficient quantities to supply the pump at its normal rate of working, which in our case was 100 to 130 cubic feet per hour. Under all conditions where the cost of a large-capacity gasometer is not prohibitive, it would doubtless be more convenient to generate the gas slowly and continuously, and then compress it, whenever the gasometer was filled. With such an arrangement it would have been more convenient even in the laboratory to use the electrolytic process. Preliminary experiments made in this direction showed that a satisfactory electrolytic cell could be easily and cheaply fitted up. This was effected by lining the sides of an ordinary stoneware mixing-pan with sheet lead, and using as a cathode a spiral coil of lead tube, covered with an inverted bell jar. From the top of this the gas is drawn off. To equip a plant to make gas at the rate mentioned above was, however, too costly for a temporary outfit. The preparation from Brunner-Mond zinc and 20 per cent arsenic-free sulphuric acid was therefore resorted to, spelter of this quality being found to give gas of high purity. Sufficiently finely granulated zinc can be obtained by pouring the molten metal into water from a height of about three feet. Three lead generators were used of the ordinary type employed for lead-burning, as shown in Fig. 2. These were arranged in parallel, and so connected that, while two were in actual use, the third was cut off, to allow the gas to displace the partially-spent acid, after which it was reconnected and one of the others turned off. By working in this manner, the required rate of generation could be maintained. The gas was found to need no purification, but was led, through two towers containing solid caustic soda, direct to the gasometer and compressor. Analysis proved the purity to be 99.8 per cent hydrogen.

Nitrogen: Commercial Manufacture and Applications.—Already at the present time nitrogen is coming into use in several of the cyanide processes, an application which will doubtless increase largely so soon as a satisfactory and economical method of generation has been devised. For, despite the apparent simplicity of the process, no very economical method of effecting the separation from the oxygen of the air is available. The older method of passing air over heated iron or copper is chiefly employed technically. In those cases where a large supply of nitrogen is needed, it would be advisable to carefully consider the employment of the waste gases from gas engines and sulphuric acid plants, which are available in quantity and contain a much reduced percentage of oxygen. It must also be borne in mind that similar gases are passed to waste in the course of manufacture of oxygen by Brin's process; while, provided any of the proposed methods of extraction of oxygen from liquid air by fractional distillation become of permanent commercial value, they will prove of direct assistance for the problem under consideration. As will be seen below, pure nitrogen can be prepared at moderate cost by an adaptation of the Harcourt method (Lupton, Chem. News, 1876, 33, 90; R. Marston, Eng. Pat. 19,074 of 1900), consisting in burning out the oxygen of the air by the hydrogen contained in ammonia. Finally, the laboratory process of generation from ammonium nitrite (K. T. Fischer and H. Alt, Ann. der Phys., 1902, [4], 9, 1149; von Knorre, Chem. Ind., 1902, 25, 531 and 550) is out of question for large scale working, owing to the prohibitive cost of material. At the recent International Chemical Congress, R. Knietsch (Chem.-Zeit., 1903, [48], 586) proposed passing air and excess of hydrogen over warmed platinized asbestos; and at the same meeting a few details were given of the process of Messrs. Elkan, of Berlin, who supply the compressed gas in cylinders.

Experimental Plant.—From preliminary trials the Harcourt method seemed to be the only one which could be fitted up in a limited space with ordinary apparatus and suitable to produce gas at a moderate cost. The plant is shown in Figs. 3 and 3a. An iron gas-pipe about 5 feet long and 2 inches internal diameter was filled with copper turnings, connections being made at one end for the introduction of air, supplied by a blower, and of the required quantity of ammonia

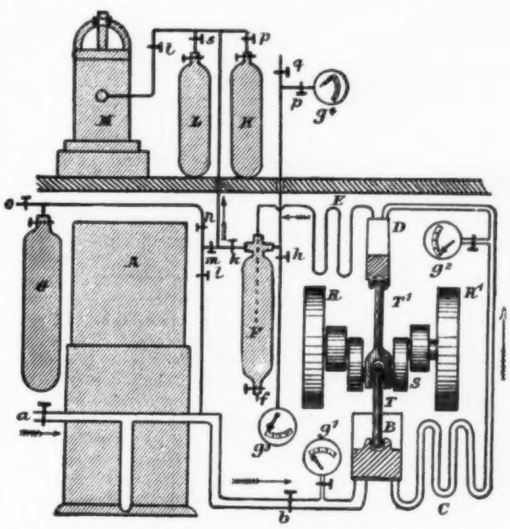


FIG. 6.—DIAGRAM OF COMPRESSING PLANT, GASOMETER AND CONNECTIONS.

A, gasometer (16 cubic feet capacity); *a*, inlet cock to gasometer from gas generating and purifying apparatus (see Fig. 3); *b*, inlet cock to compressor; g_1, vacuum gage on inlet to low-pressure cylinder; B, low-pressure cylinder; C, cooling coil for ditto; g_2, gage showing pressure at exit from low-pressure cylinder; D, high-pressure cylinder; E, cooling coil for ditto; F, water separator; *f*, water blow-off; G, gas cylinder used as auxiliary receiver; g_3, gage on high-pressure outlet; g_4, duplicate high-pressure gage; K, L, M, receivers for compressed gas; *q*, *o*, blow-off valves; R, R', pump fly-wheels; S, crank shaft; T, T', connecting and piston rods.

liquor; at the other end to condensing, washing, and drying plant, and through these to the compressor. The method works without the slightest difficulty provided that the rate of admission of air and ammonia is properly regulated. From the preliminary experiments it was found that unless the ammonia is always in considerable excess of that required theoretically, oxides of nitrogen are produced which cannot easily be removed. When gas containing such impurities is compressed serious corrosion of the valves and cylinders of the pump occurs. On the other hand, if the excess of ammonia is not removed, similar difficulties are met with. The method of working actually adopted was to admit approximately twice the theoretical amount of ammonia, and by passing a fairly rapid current of water through the washer, *J*, such part of the ammonia as was not condensed in *H* was efficiently removed, the last traces of ammonia being held back by the sulphuric acid in *L*. To regulate the quantity of ammonia necessary, a rate gage, *A*, was inserted in the air-supply pipe. This gage was of a very simple construction, and consisted of a constriction in the supply tube, each side of the constriction being connected to one limb of a U-tube containing water, the difference in heights of which indicated the rate of flow of the gas. The instrument is calibrated, once for all, by taking observations with an ordinary gas meter or gasometer. The scale of the readings depends, of course, simply on the size of the construction. As an example, one of these gages,

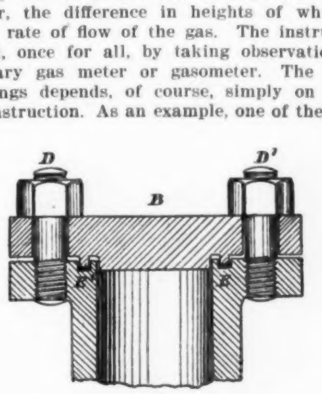


FIG. 7.—SPIGOT JOINT.

A, cylinder containing solid reagent to dry or purify a gas under pressure, or react with it; B, cover; D and D', bolts; E, spigot and spigot groove (about ⅛ inch wide for 2-inch bore, rising to ¼ or 5-16 inch for sizes up to 1 foot). The central part of the cover projects beyond the spigot, and is turned to nearly fit the bore of the cylinder. This acts as a guide when putting on the cover, and protects the spigot itself from injury when the cover is off.

having a constriction of about ⅛-inch bore, gave about 40 centimeters difference of level for a rate of 60 cubic feet per hour. Knowing in this way the rate of flow of the air, the admission of ammonia liquor was regulated by means of the graduated tube so as to supply about twice the theoretical amount. The method by which this was performed will be quite clear from the diagram. The gas obtained was entirely free from oxygen and oxides of nitrogen, but contained about 4 per cent hydrogen. This could, of course, be easily eliminated by passing through an additional tube of heated copper oxide, but for most purposes the pres-

army. It is found that cooling to —110 deg. C. is essential for complete elimination of the arsenic. (C. R., 1903, 136, 1317.)

ence of hydrogen would be of no disadvantage. For the guidance of any one employing the method in this form, we might state that in one operation some 200 cubic feet were compressed, about 9 liters of 0.880 ammonia being passed through the apparatus; the flow of gas was regulated from time to time so as to supply the pump continuously at its normal rate of working. The cost of the ammonia for 1,000 cubic feet of nitrogen would be about 17s. 6d., or half this amount if the excess of ammonia is efficiently recovered.

Carbon Monoxide: Experimental Plant.—For most chemical processes pure carbon monoxide is rarely required, some form of producer or water gas being generally employed. Where, however, the pure gas is a necessity, the manufacture of formates by the recent synthetical Goldschmidt process renders it possible to obtain it at a reasonable cost and in an extremely simple manner. The actual apparatus used is shown in diagram (Fig. 4), and consists of a bolt head, *E* (9 liters), half filled with sulphuric acid (sp. gr. 1.73). The heating was performed, either by an electric resistance furnace as represented, or by an ordinary gas furnace; the former is preferable, when working with combustible gases, where electric current is available. An electric furnace of the kind can be built up temporarily at trifling cost. The outer walls are constructed of loose firebricks; the electrodes consist of two flat pieces of boiler plate, the space between which is filled with ground coke. An electric current passing through the coke heats this up to any desired temperature. In the present case the iron plates were each 11 inches square, the distance between them being 14 inches; the layer of coke, *G*, about 40 pounds, being 7 inches deep. This gave a resistance when cold of 13 ohms and about 1.5 ohms when heated up to the working temperature. When generating gas at full rate, over 4 kilowatts are required to maintain the temperature. The reservoir, *B*, contains a supply of technical 90 per cent formic acid, from which the carbon monoxide is generated. This reservoir is kept slightly above atmospheric pressure by being connected to a supply of compressed air, thus enabling the acid to be easily forced over. The formic acid is delivered below the surface of the boiling sulphuric acid in the bolt head, the flow being regulated by the cock, *d*. The temperature, which, when the formic acid is added, of course, tends to fall, is maintained throughout the run at about 150 deg. to 170 deg. C. In this way, with a limited amount of sulphuric acid the process can be run continuously. The gas is purified in the apparatus shown in Fig. 3, the only modification being that the bottle, *L*, is in this case filled with 20 per cent caustic soda solution, and a similar solution is also allowed to drip into the quartz tower, *K* (Fig. 3), from the supply bottle, *H* (Fig. 4). Nearly the full theoretical yield of gas is obtained, about 133 pounds of 90 per cent formic acid being required per 1,000 cubic feet, costing 50s. The purity of the gas thus prepared was over 99 per cent.

Ethylene: Experimental Plant.—Up to recent years ethylene has been used in considerable quantities in connection with the production of liquid air; the apparatus which we have already described for carbon monoxides can, without modification, be employed for this preparation. There is not, however, the same latitude with regard to temperature and rate of production as in the former case. It is essential that the sulphuric acid should be kept between 160 deg. and 165 deg. C., since, even at a few degrees above this, carbonization commences, accompanied by production of sulphurous acid and carbon monoxide; at a temperature below 160 deg. C. the yield falls very rapidly, almost all the alcohol being transformed into ether. The sulphuric acid used in the bolt-head should be of such dilution as to boil at 160 deg. C. Methylated spirit is admitted through a perforated lead tube (see Fig. 4). At first scarcely any ethylene is evolved, but as part of the water in the acid becomes displaced by the alcohol, the temperature being kept constant, the rate of production gradually increases, and, after about half an hour, becomes fairly steady. A constant evolution of gas can be maintained under these conditions for any length of time, but the flow of gas is only about one-tenth of what the same-sized apparatus would produce in the case of carbon monoxide. The yield obtained was not much more than half the theoretical. An addition of ferrous sulphate to the sulphuric acid has been proposed by R. N. Lennox as insuring against carbonization and evolution of sulphurous acid. This addition seems to be a considerable improvement on the original process. The acid mixture is made with concentrated sulphuric acid (sp. gr. 1.84) and sufficient saturated ferrous sulphate solution to bring the boiling point down to 160 deg. C.

Another method proposed by Newth (G. S. Newth, J. Chem. Soc., 1901, 79, 915), which consists in employing syrupy phosphoric acid in place of sulphuric acid, was tried in the same apparatus. The temperature should be kept between 200 deg. and 220 deg. C.; there is no carbonization, but a considerable amount of ether is collected. The yield in this case was even lower than with the sulphuric acid method, but the process can be worked quite continuously, and the quantity of phosphoric acid required is not large.

Notes on Various Other Gases.—The foregoing deals with the preparation of such gases as cannot easily be obtained commercially. With regard to many other gases similar methods could of course be adopted, but producing them on the scale with which we have been dealing would hardly repay the trouble involved, in those cases where they are already on the market. Further, for such gases as sulphurous acid, chlorine, and ammonia, a special pump would be necessary; and even before oxygen could be compressed, much time would have to be spent in carefully removing all traces of organic matter from the pump cylinders, connections, and gages.

Oxygen, nitrous oxide, carbonic acid, sulphurous acid, and ammonia can readily be obtained from the various companies in this country who make a specialty of their manufacture. Where a compressed gas is not required, oxygen in a similar way to acetylene can be produced by the action of water on one of its solid compounds. A French company has recently put on the market a mixture of sodium peroxide and bleaching powder, under the name of "oxylith," which yields oxygen of satisfactory purity. The cost of the gas produced by this method (5s. 9d. per 20 cubic feet) would, however, be prohibitive where a large quantity is required. So far as acetylene is concerned, it will be recalled that, as a result of the exhaustive investigations which followed on numerous and disastrous accidents, Berthelot and Vieille showed that it is highly dangerous to compress this gas above four atmospheres. The gas, however, can now be stored in cylinders, filled with some porous material saturated with acetone, this liquid absorbing about twenty-four times its own volume of gas per atmosphere pressure (A. Janet, Génie Civil, 1903, 43, 180). In Germany (O. N. Witt, Die Chemische Industrie des deutschen Reiches im Beginne des 20 Jahrhunderts, pp. 100-105) considerable use has been made in recent years of liquid chlorine, which is produced by several companies, and notably by the Badische Anilin Company, and can be obtained retail (e. g., Kahlbaum, Berlin) for 1s. 6d. per pound in bombs of 20 pounds or over. Methyl chloride (2s. per pound, Douane, Paris), phosgene (Kahlbaum, 6s. per pound), and ethyl chloride (2s. per pound) can all be obtained commercially, and find uses particularly in the color industries and for refrigeration.

Compression and Storage of Gases.—The portion of the subject which we have to deal with now is of rather a special nature. Much of the information given below will be well known to those few who have been connected with commercial gas-compression plants; but now that pumps can be obtained at a moderate cost and of sufficiently simple construction to give no trouble for continuous working, there is no reason why the great convenience of storing gas in the compressed state should not be more generally made use of. For work of this kind, the smallest convenient plant comprises:

(1) Compressor capable of dealing with 60 to 130 cubic feet per hour, and of working up to 120 or 200 atmospheres.

(2) A small gas-holder (10 to 20 cubic feet capacity), which is used, not to store the gas, but to act as an equalizer between the pump and generating apparatus. It being assumed that, wherever possible, the gas is made and pumped at the same rate.

(3) A stock of weldless steel gas cylinders.

As a general guidance with regard to cost, the price of the compressor may range from £60 to £100, and the gasometer from £10 to £20. For most purposes it is convenient not to exceed the commercial pressure of 120 atmospheres. For this pressure, gas cylinders, ready fitted with valves, can be obtained at about 1s. per cubic foot of gas stored, when purchased in small quantities; or at half this price when bought on a larger scale. For higher pressures, the cylinders have to be made to order, and are correspondingly more expensive. Another £10 to £20 should be allowed for the purchase of two or three pressure-gages, a dozen cone connections, eight or ten high-pressure valves, and the capillary copper tubing which serves to conduct the gas from the compressor into the receivers. Weldless copper tubing of 1/16-inch bore and 1/4-inch external diameter is both strong and large enough for this purpose, and can be readily obtained from any copper tube manufacturer. This size has the further advantage, when annealed, of being quite flexible, and can thus be bent, whenever used, to the most convenient shape. The ends of each length of such tubing are soldered into brass or gun-metal cones, as shown in Fig. 5. These are screwed to the cylinder or pump valves by a nut which surrounds them. In a plant of the kind it is advisable to keep to a standard size, "half-inch gas" being most convenient for this purpose.

An ordinary air-pump is, of course, not suitable for dealing with combustible gases. The cylinders of the compressor should be entirely closed, the piston-rods passing through properly-made stuffing-boxes. The smaller compressors are usually of the tandem two-stage type, the low-pressure cylinder compressing to about seven atmospheres, the gas being then passed through a cooling coil into the high-pressure cylinder, which forces it up to the full pressure. The high-pressure cylinder delivers its gas, through another copper coil immersed in a cooling tank, into a small gas cylinder, which serves to separate the water used to lubricate the pump. At the bottom of this separator is a valve for withdrawing the water. If the pump is required to suck in its supply of gas under a partial vacuum, the low-pressure inlet valve should be arranged so as to be mechanically lifted at the top of each stroke. The water for lubricating the cylinders is fed through a sight feed, and for a compressor of the size we are dealing with, a single drop per two or three revolutions is an ample supply. The clearances should, in both cylinders, be about 1-32 inch, or at any rate not exceed 1-16 inch, in order that, at the highest working pressures, the pump may deliver its full volume, and not compress and expand the same gas.

The following precautions are of the highest importance from the point of view of safe and satisfactory performance:

(1) The greatest care must be taken never to allow much more than the above-mentioned quantity of lubricating water to enter, as with such small clearances this water carried into the high-pressure cylinder would be unable to pass through the narrow outlet valve and would burst the cover or bend the crankshaft.

(2) If the apparatus is to be used for air, or more especially for oxygen, it is of vital importance that no oil should be employed, either in the pump cylinders or in any of the valves, connections, or gages. Many disastrous explosions have resulted from the neglect of these precautions. The water may, however, if desired, be replaced for lubrication by glycerine, which forms an excellent substitute for oil for this purpose.

(3) Each time before running the pump, it is advisable to turn it through one or two revolutions by hand to insure that it is working freely. If the gas to be pumped is combustible, before connecting to the gasholder the pump should be run for a minute or two with the inlet cock closed, and the end of the delivery pipe placed under water. In this case, if the stuffing boxes and connections are satisfactorily tight, the pump will be running under a vacuum and should deliver absolutely no gas.

(4) The purity of any combustible gas must of course be properly ascertained, as any admixture with air would lead to serious explosions.

(5) It is very advisable to adopt the excellent system, employed by all the gas-compressing companies, of distinguishing between combustible and non-combustible gases, by invariably storing the former in cylinders characterized by a bright red color, and fitted with left-handed connections. Even where this is done it is advisable before connecting a partially-filled cylinder with the pump to test its contents at a flame.

(6) All storage cylinders, connections, and other apparatus, with the exception of gages, should be occasionally tested hydraulically to double the maximum working pressure.

So far as the actual compressing is concerned, a clear idea will be obtained from the diagrammatic sketch (Fig. 6). The gas passes from the purifying apparatus shown in Fig. 3 to the gasometer, *A* (Fig. 6), from which the two-stage compressor, driven by an electric motor, forces it into the water separator, *F*. At its exit from this separator the gas is sufficiently dry for almost any purpose for which it may be required, since the percentage of aqueous vapor in a gas at 100 atmospheres is only 1-100 of its amount at ordinary pressure. When the gas is being made at the normal rate the valve *k* is kept open, the valve *m* closed, and the gas passed directly into a storage cylinder such as *L* or *K*, or, in the case of our own work, direct into the pressure furnace, *M*. These were situated in the room on the next floor of the building to the compressor. A high-pressure connection is also led direct to a duplicate gage g_1, by which the pump pressure can be independently read. When necessary the gas can be blown off from the valves *q* on the upper floor, or *o* on the lower; *o* being connected to a pipe leading outside the building, for use with poisonous gases such as carbon monoxide. If, for any reason, the supply of gas falls below the normal rate, the valves *m* and *l* are partially opened, *n* being kept closed; a part of the gas delivered by the pump then returns to the gasometer, and is compressed again, thus avoiding the necessity of either stopping the pump or working it under a partial vacuum. When dealing with gases which can only be conveniently kept closed. This last method of working is of course necessary to give up any idea of continuous pumping. In these cases the gasometer is allowed to fill slowly; the pump is then started, and stopped a few minutes afterward, so soon as all the gas has been pumped. The storage cylinder is thus filled step by step up to any desired pressure. It is not possible to restart the pump against a high pressure; the gas contained in the water separator, *F*, must therefore be blown off, and since, at a high pressure, the volume thus returned to so small a gasometer would take up a large part of its capacity, it is preferable to employ an auxiliary cylinder, *G*, which takes the major part of the contents of *F*, the residue only being returned to the gasometer by the valves *k*, *m*, and *l*. The contents of *G* can be returned to the gasometer and pumped during the course of the next run through the valves *n* and *l*, *m* being kept closed. This last method of working is of course somewhat complicated, but has proved very useful in a few cases where it was practically impossible to produce the gas at the normal rate. For those purposes where it is required to study some chemical reaction or to purify a gas when under high pressure, a gas cylinder with a removable cover is employed. The ordinary cone joint as shown in Fig. 5 works satisfactorily to close the opening of any tube up to one-inch bore. Above this size it is necessary to resort to some form of spigot joint, such as is shown in Fig. 7. One or two turns of lead wire about the same diameter as the groove are inserted in it, the ends of the lead being beveled so as to overlap each other. The cover is then forced home by means of the bolts provided for the purpose, and, crushing the lead outward and upward, forms a gas-tight joint. When making such a joint for the first time, exceptional care must be taken that the nuts are pulled down evenly, as otherwise the cover may be strained or, being out of true, the joint will not be gas-tight. When the cover has once been fitted correctly, it can be removed and replaced some hundred times before it is necessary to add fresh lead packing. We have used joints of this kind up to a foot diameter, which have always worked satisfactorily.

Above this diameter the weight of the cover and the size of bolts required become somewhat unmanageable when designed for pressures of 100 or 200 atmospheres. —Electrochemical Laboratory, The University, Manchester.

DIAMONDS AND THE DIAMOND INDUSTRY.*

IN 1475 Louis de Berquem invented the great art of diamond polishing, and in 1476 established at Antwerp the earliest known works for the purpose of cutting and polishing diamonds. The disturbed state of that part of Flanders drove the diamond industry to Amsterdam, where it flourished uninterruptedly for upward of three centuries. It was not until the independence of Belgium was established in 1830 that Antwerp began to recover its position as the headquarters of the diamond industry. After the discovery in 1870 of diamond mines in Cape Colony, the wages earned by skilled workmen at Antwerp increased to so great an extent that some of the workmen are said to have earned wages amounting to as much as from £40 to £48 a week. Since that time the diamond trade of Antwerp has continued to increase in importance, and it now equals that of Amsterdam. The whole European diamond trade is centered in these two towns.

Diamond cutting is divided into three separate and distinct processes—(1) cleaving, (2) brutage, (3) cutting and polishing. Cleaving is the act of dividing the layers or scales which form the crystal, an operation which can only be performed in one manner on account of the flaky formation of the diamond. The stones have to be divided in accordance with the running grain of carbon of which they are composed, and any attempt to divide them in another way would result in their being split and destroyed. A diamond is cleft as follows:

The rough stone is placed in a small metal receptacle, with the side of the diamond which it is desired to cut facing downward. Over this receptacle is placed a shaped mold which is securely attached to it. Into the top of this mold is then poured liquid aluminium, which runs into the shape of the mold and, after being cooled, securely holds the diamond in the required position. The mold is then removed and the stone remains fixed in the aluminium ready to be applied to the cutting tool. The machine used for the cleaving is a small circular saw of about four to five inches in diameter, which rotates at a high rate of speed and is driven in the ordinary way by a leather belt from the running machinery. The saw itself is made of fairly soft copper with a prepared edge. To prepare the cutting edge of the circular saw it is necessary for it to go through a special process by which diamond dust mingled with oil is forced into its edge. "Diamond cuts diamond" as, after the preparation of the saw, its cutting edge is embedded with minute grains of diamond dust. The diamond is then applied to the saw in a similar manner to that in which wood is placed against a circular saw in a mill, with the slight difference that the diamond is held immovable in an instrument overhanging the saw which presses it gently against the blade. It frequently takes two weeks continual work to cleave a diamond, the duration of the time depending entirely on the hardness of the substance of the stone to be cut. The most difficult stones to cut are those of double formation, the grain of which is interlaced, thereby creating greater resistance. The machine used was invented some years ago in America by a Belgian who was at the time working in the United States. Before its invention diamond dust for the finishing process was often most difficult to obtain, and manufacturers had frequently to grind fragments of inferior diamonds by means of a hardened steel pestle and mortar, but nowadays the supply of diamond dust is always abundant, not only "for the requirements of the factories, but even to be disposed of for use in other industries, such as glass-cutting." Before the coming into use of the machine referred to, the whole of the process of "brutage" had to be performed by hand, and was most monotonous and tiring work, the shaping of larger stones in particular necessitating a great loss both in time and labor.

The second process in the preparation of a diamond is its primary formation before it is ready for the first cutting and polishing, and the operation is carried out by means of mechanically rubbing one stone against another until the desired formation is achieved. Before the "brutage" takes place the stones are received either in their rough state, save that they have been washed clean, or else from the cleaning department in so many small pieces. The mode of procedure is as follows: Two diamonds may be taken of similar size and equally hard in substance. Each stone is fitted into a brass or other metal cap by melting cement in a gas flame, which is then dropped into the aperture of the cap, the diamond being fixed in the cement, which is afterward cooled and set by being plunged into cold water. Thus, two diamonds of equal dimensions are firmly fixed each in a separate metal cap or holder. One of these stones is then attached, by means of the cap which holds it, to a rotary machine, the stone forming the revolving center. The other stone is fitted to a long handle or holder, and is placed against the revolving stone in the required position in a similar manner to that in which the tool is applied when cutting wood or metal in a lathe. The diamond dust which is produced by the rubbing of the stones together falls into a copper box called an "eglisoir," or diamond dust box, which is placed immediately below the diamonds being worked. This dust is carefully preserved, and it is eventually used in the third operation of cutting and polishing.

Cutting and polishing is the third and last operation in the preparation of a diamond previous to its sale. In this process the stone, which has been roughly shaped by the second operation, is placed in position at the required angle in a copper holder with which it is firmly pressed by means of a forked clamp, which is pressed against the stone and locked into position with a key. Great skill is required on the part of the workman in fixing the diamond into the holder. Many stones of one-eighth of an inch and less in diameter, weighing between 1 and 2 grains, have as many as 50 to 100 facets or separate cut faces, each at a different angle. Continual practice, however, facilitates this operation, and a skilled workman can immediately place the stone in the holder at the required angle ready for the cutting of another facet. When the stone is ready in the holder it is placed against a revolving disk of soft steel rotating in a horizontal position at a speed of some 3,000 revolutions a minute, and is left there until the required facet is cut and polished. The surface of this disk is prepared with a mixture of diamond dust and purified olive oil, which is rubbed into the steel, and it is this dust, which comes in the form of waste from the second operation of "brutage," that effects the polishing of the stones.

In olden times diamond cutters contented themselves with cutting as large a number as possible of small facets on the surface of a stone, regardless of regularity, and without taking into account its form or size, but it is now recognized that to obtain the best results and sparkling glitter, a diamond must be cut in a regular form, so that one surface may reflect on another, thereby showing forth the hidden light and beauty of the stone. There are two common forms of cutting diamonds, it may almost be said there are only two forms, the brilliant and the rose, the brilliant for stones of a certain uniform thickness, and the rose for flatter stones and layers which have been cut from other and larger diamonds. The cutting of a brilliant is a process which best shows forth the lights and reflections contained in a diamond. A perfectly formed brilliant should have the proportions in depth from the upper surface or summit to the lower point called the pyramid or pavilion of two-thirds of the diameter of the stone at the belt or middle. The summit, or crown, of a brilliant should have 32 facets, and in addition one large central facet called the table. From the side of the pyramid it should have 24 facets and one small facet at the lower point called the "colette," making in all 58 facets, and not, as has sometimes been stated, 64 facets. These facets should be calculated, divided, and regularly cut in such a manner that those cut on the pavilion of a diamond may reflect the light on to the facets cut on a summit, and *vice versa*, thus showing forth in as high a degree as possible the sparkle and glitter of the gem. All diamonds are cut in a series of stars, one being formed over the other. On looking through the flat surface, or table of a properly cut brilliant the "colette" or lowest point should appear to be directly in the center of the table. In the regular cutting of these facets depends the whole beauty of a diamond, and in their formation lies the secret and difficulty of the diamond trade. The rose is a more useful form of cutting diamonds, of less value and thinner formation, and is cut with one large facet at the base and 24 triangular facets on the summit. The thicker stones cut in this manner, with 24 facets, are called on the Continent "Roses Couronnées." Those which are only cut with twelve or six facets are known by the name of "Roses d'Anvers," and form one of the chief specialties of Antwerp. The quality and value of a diamond may be roughly determined by examining it against the light. In a stone of inferior value there appear to be many lines or scratches, whereas the more perfect stone is recognized by its purity and lack of marks in the grain, and also by its regularity of formation.

The bulk of the diamonds worked in Belgium and the Netherlands originate from British possessions, or mines owned by British subjects. The diamonds, after being cleaned and weighed in their country of origin, are sent to merchants in London, where they are sorted and put up for sale. The stones are then invariably purchased by foreign merchants who have their factories abroad. Thus although the stones come first to the United Kingdom, they are afterward conveyed abroad to be cut and prepared, and then in many cases returned to the United Kingdom to be sold by retail dealers. By this practice the whole of the diamond industry, with its profits, is lost to the United Kingdom. It can hardly be said that low wages prevent British competition in the diamond industry. The average wages paid to diamond workers in Antwerp range from £2 12s. to £2 16s. per week. The diamond cutters are paid from £2 8s. to £3 4s. per week, the shavers from £4 per week upward, and the sorters are paid wages varying from £1 5s. to £2 per week. The workers employed in all the branches of the industry at Antwerp, number from 4,000 to 5,000, including some 70 women employed on the lighter work. No precautions are, or can be taken, to guard against dishonesty in the workers, but cases of dishonesty practically never occur. It is difficult to state the names of the countries to which diamonds cut at Antwerp are sent, or the value of the stones exported, as no statistics on the subject are published. A diamond is so small an object, and one of so great value, that practically all the diamonds exported are sent out of the country without the knowledge of the customs officials. In the customs returns for 1903, is a note which states that owing to the existing conditions of the export of cut diamonds it is impossible to give details of their value, but that from information received, it is estimated that the value of the exports during that year amounted to £3,340,000. Precious stones are admitted free of duty in Belgium, and there seems to be no sufficient reason why this valuable industry should not be carried on in the United Kingdom. It ought to be possible for the British workman to learn the art of diamond cutting in spite of the secrecy adopted by the diamond cutters as to their method of cutting.—Journal of the Society of Arts.

* The statements of fact made in this paper rest upon the report of British Consul-General Hertslet on the diamond industry of Antwerp, just published (No. 634, Miscellaneous Series).

A NOVEL FLOATING EXPOSITION.

THE Export Shipping Company, of New York, advises the Department of Commerce and Labor that the company has decided to adopt a suggestion made by an officer of the department in an article appearing in the Geographic Magazine in 1901. It is proposed to equip a large steamer and furnish space thereon to American manufacturers to make a display of their products and then send them around the world on a 60,000-mile trip, to consume about fifteen months. In answer to numerous inquiries received by the Bureau of Manufactures, the following explanation of the enterprise is offered:

The plan is to allow each person who subscribes for 40 square feet of space or more to display his goods and to send on the steamer a representative whose duty it will be to see that the exhibit is properly arranged at each port, to meet the merchants and dealers invited to inspect the exhibits, explain the utility and advantages of the goods, quote prices delivered in the country of consumption, terms under which goods are sold, appoint agents, extend the sale of the goods, ascertain what the markets of the country demand, the competition to be met, etc. This representative shall also satisfy himself by a personal investigation that any agent so appointed to represent his principal shall be of good character and financially able to meet his obligations. If the standing of agents is carefully gone into there should be no objection to extending ordinary business credit, and no more risk in doing so than is experienced in granting time payments to domestic customers.

The undertaking is likely to create wide interest in the commercial world, and its progress will be watched keenly by the various trade journals and newspapers, so that every merchant in the countries visited will be familiar with the fact that the exposition is to call at his port. In these circumstances it will not be a hard matter to induce him to visit the ship. The date of arrival in the ports will be advertised, and all interested will be advised to obtain tickets of admission at the newspaper offices, the chamber of commerce, the American consulate, or at the office of the Export Shipping Company. It is also proposed to print, in the language of each country, a catalogue showing the name of each exhibitor, the name of his representative, the position of the display in the ship, and a full description of the goods exhibited. As in some instances it will not be possible to obtain direct land communication, it will be necessary to bring the visitors off in launches, which will also necessitate serving lunch on the steamer as well as insuring sufficient time for each visitor to examine thoroughly each and every exhibit on the ship. The luncheon should provide a most excellent opportunity for the demonstration of American food products.

All firms participating will be required to conform to reasonable rules, and the representatives on the ship will be afforded opportunity to acquire a knowledge of French, Spanish, and German and are expected to improve it. In this way such representatives will gain knowledge of trade conditions and the ability to answer letters, upon returning home, in the language of the inquiry. If in any cases sufficient sales are not consummated while on the trip to reimburse the participants for their expenditure, at least the seed will be sown in fertile ground, which will bear fruit in years to come. The plan will appeal particularly to firms who already have an export trade and agents in the different countries, as the agents would assuredly be flattered to receive a visit from the representative of the manufacturers, and the opportunity would afford a splendid chance for calling the attention of his customers and others interested to the display, and also allow him to explain on the spot what special facilities or changes in standard goods or manner of putting on sale will lead to an increase in business.

The expense of the trip is to be borne entirely by sale of space on a mutual basis. The available space is 20,000 square feet and the price is fixed at $50 per square foot. The prospectus of the promoters shows in detail the estimated expenses, and the surplus remaining at the termination of the trip is to be returned to those who participate *pro rata*. It is expected that the net cost of space will not exceed $35 per square foot of space and $500 for meals and incidental expenses of the representative. This, on a basis of 40 square feet of space, means that the entire cost for traveling expenses and showing samples will be about $5 a day.

The exhibits will be cared for and all necessary janitor service, lighting, and a limited amount of power for working exhibits will be furnished without

extra expense. The promoters call attention to the fact that the enterprise is not designed as a money-making plan, but is intended to be a dignified, broad-minded plan to further the cause of America's export trade.

It is desired, and efforts are being made, to have the exposition representative of as many different lines of prominent American manufacturers as possible or practicable, and to have the exhibits arranged in such a manner that the attention of interested merchants in foreign countries will be held and impressed thereby.

The itinerary provides for stops at ports of the most important commercial countries of the world.

LARVÆ AND PUPÆ OF FORMICA SUBSERICEA, ENLARGED.

THE SENSE OF SMELL IN ANTS.*

By ADELE M. FIELDE.

ANTS possess all known senses except that of hearing. Leading a life that is mainly subterranean, they have little need of ears, and are compensated for their lack by a marvelous sensitivity to vibrations reaching them through the solids on which they stand.

Their sight is less keen than that of many other insects, and a motionless enemy a half inch distant may remain undiscovered. The light by which they see is not perceptible to human eyes, being ultra-violet.

The ants make their way in the world and thrive vastly in all countries and nearly all climates by merely following their noses, which are more highly endowed than is the same organ in any other creature whose power of smell has been tested.

The ant's pair of noses, called antennæ, project from its face below the eyes and are jointed. Among the thirty-five hundred described species of ants the joints vary in number from four to thirteen, the number being always the same in the species and sex. Each antenna is a competent nose, and each joint of an antenna appears to have a special function, or to be a sub-nose devoted to a particular use.

In 1901 I discovered the functions of several of these joints, using for my research work the common brown ant, *Stenamma fulvum*, which has twelve joints in its antennæ.

When an ant is removed from its own nest and afterward returned thereto, it immediately seeks its old comrades in the deeper recesses and is manifestly at ease in its environment. It waves its antennæ and recognizes in the air the diffused odor of its home. But if the same ant be dropped into any other ant-nest it instantly runs away, and, if it be unable to escape, tries to hide itself. It smells an alien nest odor and is afraid. But if the final, the twelfth, joint of the antennæ be cut off, and the ant kept in hospital till it has recovered perfect health and activity, it will then be unable to discern the difference in the odors of ant-nests and will behave alike toward all. It has lost the sub-nose, whose function is to reveal the proper domicile to the ant inhabitant.

The next, the penultimate joint, is the sub-nose that discriminates between the ant's personal relatives and those of its own species who do not belong to its community. As quickly and as surely as a man recognizes his friends and takes more or less pleasure in meeting them, so does an ant recognize its comrades and evince delight in their companionship. But the ant recognizes also the odor of blood relatives that it has never before met. This sub-nose performs its function only when in contact with some part of the body of the individual under consideration. It touches the newcomer, and if the odor or savor be familiar, patting and caressing may follow, while if the odor be unfamiliar a battle that may last hours or days is likely to ensue. If this penultimate joint be removed the ant thus maimed ceases to discriminate between its blood relations and ants of other communities of its own species, and will permit ants from distant colonies of its kind to share its domestic cares and joys.

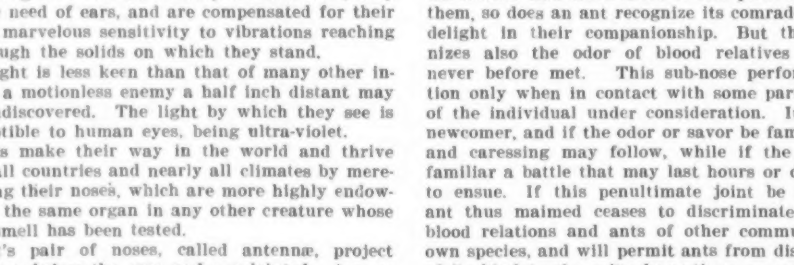
The third joint from the distal end, the antepenultimate, smells through the air the scent laid down by the feet of the individual and upon the path which it traverses. An ant may make long journeys from its abode, and, so long as its track is unbroken, it can return thereupon to its starting point. A thin layer of dry earth may be sprinkled upon the track and the ant can still follow the scent, but if the track be washed away for a stretch greater than the length of the ant, then the little traveler is lost and can proceed homeward only when the scent is again picked up. Over an undisturbed area ants may go to and fro on tracks laid down many days previously; each ant following its individual scent. But if the third sub-nose be removed, the ant is no longer able to follow its track, and it goes out and in no more. It behaves like a blind person in the midst of his fellows.

The next two joints, the fourth and fifth, are those that smell the inert, developing young, and probably also the queen mother, having the same odor. So long as these sub-noses are intact, the ants clean, tend, and feed their infants with more than human assiduity. But after these sub-noses are removed the most diligent nurses cease attending to the ant-children and never afterward show the slightest interest in the work of the nursery. They no longer discern the eggs, larvæ or pupæ to whose care they were formerly devoted.

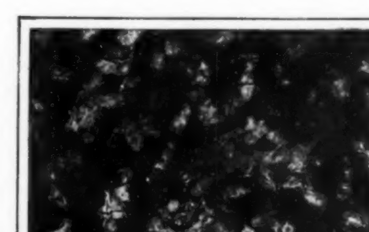
ANTENNA OF STENAMMA FULVUM.

A WORKER ANT.—CAMPONOTUS PENNSYLVANIEUS.

Next above these joints lie the two that perceive presumable enemies, such ants as are of alien species and therefore predatory, rapacious, or hostile. All normal ants detest strangers, and, with well founded fear of personal injury from them, they avoid or attack every ant of a species other than their own. But when these two sub-noses are removed, and the ants have recovered from the involved surgery, ants of many species and even of different sub-families will live together in harmony, regurgitating food to one



CAMPONOTUS AMERICANUS.—WINGED QUEENS AND FOUR PAIRS OF WORKERS, ENGAGED IN REGURGITATING.

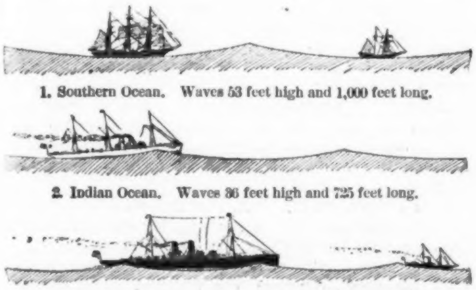


STENAMMA FULVUM, SOMEWHAT MAGNIFIED.

* From the Independent.

another and behaving as if they had all hatched in the same nest. Animosity toward strangers has been eliminated by the removal of the sub-nose that made the strange ant odor apparent. This sub-nose, like the second, performs its function only when in contact with the body of the stranger.

There is little doubt that ants orient themselves



1. Southern Ocean. Waves 53 feet high and 1,000 feet long.

2. Indian Ocean. Waves 36 feet high and 725 feet long.

3. North Atlantic. Waves 26 feet high and 528 feet long.

FIG. 1.—STORM WAVES.

(The waves and the vessels are drawn to the same scale.)

when on their journeys by the sense of smell, the same as men do by the sense of sight.

After an ant is deprived by aseptic surgery of a portion of its organs of smell, it takes two or three weeks for it to recover its normal health, even in the best of ant hospitals and under the care of a highly trained nurse. But a protected ant has lived in one of my *hotels des invalides* a full year without a nose. One of the two antennæ is often lost by ants living in natural conditions, the prominence and delicacy of the organ making it peculiarly subject to injury in battle. But I have never found in natural nests a live ant that lacked both antennæ.

The long shaft, or scape, the joint nearest the head, does not smell, and its use is probably purely mechanical. This may be true also in many-jointed antennæ of the joints nearest the scape.

The antennæ are full of nerve-cells and fibers that connect with the ant's brain, lying near the proximal end of the antennæ.

The sense of smell appears to do for the ant about all that the sense of sight does for man. It serves the ants in their dark abodes much better than could that of sight, and through its marvelously high development renders them most capable administrators of their own affairs.

RHYTHMIC MOVEMENTS OF THE SEA.

By A. BERGET.

THE surface of the sea is never absolutely at rest; not a molecule of its waters is ever motionless. Even when it presents that exceptional appearance, like a polished mirror, which the Provençals so aptly call a "sea of oil" (*mer d'huile*), its waters are subjected, by the action of currents, to a general movement of translation over the earth's surface while, at the same time, they rise or fall under the attractive force of the nearest heavenly bodies.

In this article we shall leave out of consideration the movement of translation, that is to say, the ocean currents, and confine our attention to those motions of the sea which are periodic. Of these there are two sorts. The movements of short period, due to the action of winds, give the surface of the sea the diversified appearance expressed by the terms swell, rollers, and waves. The movements of long period, due to cosmical forces, constitute the tides.

The appearance of the "sea of oil" can exist only when the atmosphere which rests upon the ocean's surface is absolutely at rest. The lightest conceivable breeze heaps up and pushes before it the particles of water, to which it adheres slightly, and these particles

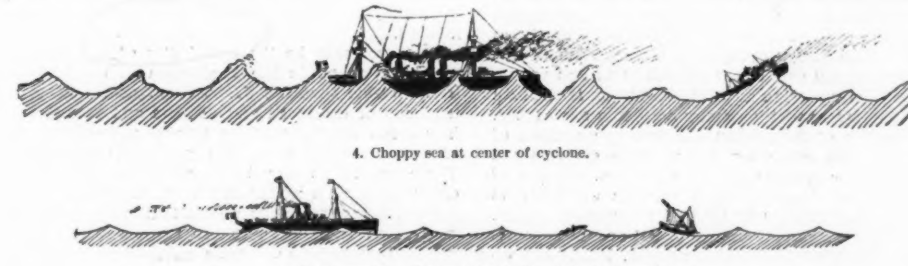
FIG. 2.—BREACH MADE IN THE SEA WALL OF CHERBOURG BY THE WAVES IN THE GREAT STORM OF 1894.

FIG. 3.—FISSURE MADE IN THE WESTERN JETTY AT CHERBOURG DURING THE STORM OF 1894.

unite to form a ripple which is driven over the surface of the sea by the action of the very wind which gave it birth.

If the wind increases in force, or "freshens," to use the graphic and precise language of sailors, neighboring ripples unite and form a sort of ridge which travels over the surface of the sea, displacing the liquid particles vertically. Thus arises the "swell" of the sea.

If the wind increases still further in violence, the rollers of the swell become hollowed, the rounded summit of the ridge breaks under the impact of the atmospheric currents, and the formidable mountains of water thus formed are called waves.



4. Choppy sea at center of cyclone.

5. Mediterranean. Waves 16 feet high and 165 feet long.

FIG. 4.—STORM WAVES.

The swell is the most regular phenomenon. It manifests itself in all its grandeur in the tropical seas where, in a dead calm, the surface of the water is disturbed by undulations propagated by waves coming from afar. At a great distance from their place of origin waves become more regular and form a rhythmical swell. The sea appears to rise and fall during

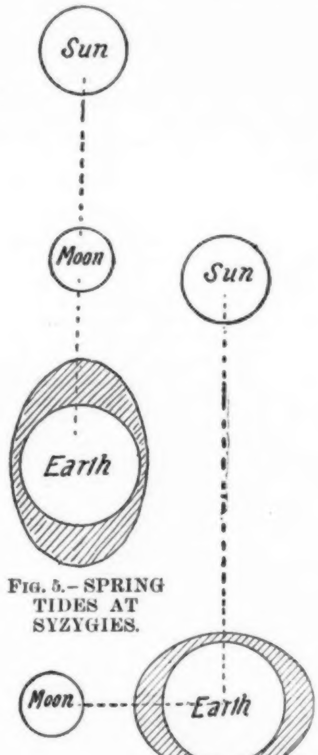


FIG. 5.—SPRING TIDES AT SYZYGIES.

FIG. 6.—NEAP TIDES AT THE QUADRATURES.

the passage of the liquid ridges which extend in length from horizon to horizon and seem to flee the glance of the observer. In reality, what moves along is not matter, but motion. If a cork is thrown into the sea it is seen to rise on the crests of successive rollers and sink into the valleys between them, but it remains at the same point of the surface, proving that there is no translation of the liquid particles, but merely a propagation of the motion from one particle to another. The philosophers of the middle ages divined this fact and expressed it in the formula, *non materia ipsa progrediens, sed forma materia progrediens*" ("not matter itself, but the form of matter moving onward").

To this regular phenomenon correspond regular characteristics which can be expressed numerically. Thus we can measure the wave-length, or distance between two consecutive crests; the velocity, that is, the distance traversed in a second by the apparent motion of the swell; the period, or the number of seconds which intervene between the passage of a fixed point by two consecutive crests; and, finally, the amplitude, or height of the roller.

The particles of water describe small circles about fixed centers. These circles are flattened in proportion to the depth below the surface and become straight lines at a certain depth. It has been ascertained by exact experiment that the motion is perceptible to a depth equal to 300 times the height of the waves—a fact to which regard should be paid in laying telegraphic cables in moderately shallow waters.

When the wind increases in force the rollers of the swell no longer correspond to a vibratory movement of the molecules but behave like vessels driving before the wind. To the local vibratory motion of the molecules a movement of translation is added; the

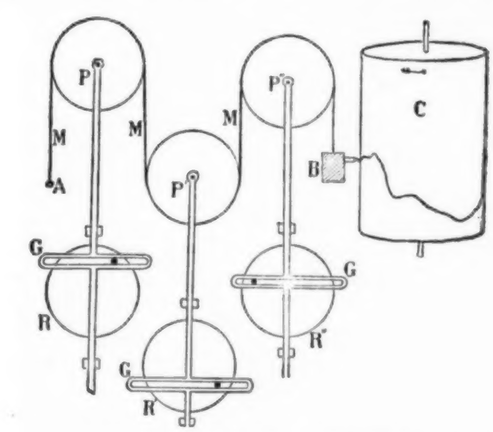


FIG. 7.—THE TIDE PREDICTER.

R, R', R'' are wheels which drive, by means of the pins and slides G, G', G'', the rods which carry the pulleys P, P', P''. M is a cord which engages with all the pulleys, B a weight carrying a pencil, C the rotating cylinder on which the tidal curve is inscribed.

waves lose their regularity and "break," as sailors say. Their crests are crowned with foam and they increase greatly in height and length.

In the Southern Ocean, south of Cape Horn and the Cape of Good Hope, in that vast expanse of water where no continent interrupts the regular movement of the waters, are found the largest waves that human eyes have ever beheld. Here Dumont d'Urville measured waves 60 feet in height—as high as a five-story house. Their length was from 1,000 to 1,100 feet, or nearly twenty times their height, and their velocities from 20 to 25 nautical miles an hour.

A very exaggerated conception is often formed of the appearance of waves, which we are tempted to represent as walls of water which fall upon vessels and engulf them. In reality, the mountains of the sea are by no means steep. Fig. 1 gives, drawn to scale, the profiles of waves 53 feet high, as observed by Lieut. Pâris and, on the same scale, a three-master 250 feet

long and of 2,000 tons displacement, and an Iceland fishing smack.

Below are shown waves of the Indian Ocean 36 feet high, measured during heavy weather, in comparison with a "Messageries Maritimes" liner; and Atlantic waves, which rarely exceed 26 feet in height, compared with the transatlantic liner "La Touraine." It is evident that so long as these vessels move in the same direction as the waves they are little affected by them. The frequent flooding of the deck by sheets of water which sweep everything before them is due to steaming at full speed against both wind and waves. The latter, encountering an obstacle, attack it with all their momentum, and thus many accidents are caused.

As a matter of fact, when the free propagation of waves is interrupted, when the wave meets either a solid obstacle or another system of waves, the law of the phenomena changes. Each particle of water is acted upon simultaneously by two systems of forces. If the velocities due to these are equal and in opposite directions the particle remains at rest, but if the velocities are in the same direction they are added together and the amplitude of the wave motion is increased.

This is what occurs, especially in the vicinity of a coast, which the waves strike normally. They are reflected and give rise to a second system of waves, traveling in the opposite direction. Therefore the sea is always rougher near the coast. Moreover, the waves break into foam as they dash furiously on the rocks, and throw up spray, in violent storms, to a height of 90, 100, even 150 feet.

The crushing force of such breakers is astonishing. Blocks weighing twenty or thirty tons are rolled like pebbles by these huge billows which exert pressures of three tons to the square foot. The photographs (Figs. 2 and 3) of the breaches made in the sea wall at Cherbourg by the great storm of 1894 are more eloquent than words.

A phenomenon of interference of this sort is the cause of the baffling or "choppy" sea which is encountered in the center of a cyclone (Fig. 4).

In a cyclone the wind blows from every direction. It, therefore, generates an infinite number of systems of waves, which meet and interfere at the center, where the waves rise to heights of 70 and 80 feet and more, and follow each other at very short and irregular intervals. The battleship and the torpedo boat in the illustration are drawn to the same scale as the waves.

Below are shown storm waves of the Mediterranean, compared with a packet of an Algerian line. The waves are short, because of the interference of numerous systems of waves due to reflection of the principal wave system by the coasts of this inclosed sea.

Sailors have found a way to moderate, temporarily, the fury of the sea in a storm. They pour oil upon the troubled waters. The oil spreads out in a thin film over the surface of the sea and diminishes the friction between wind and water. A few quarts of oil enable a vessel to ride the storm for several hours.

The movements of the sea of which we have spoken are of short period. There are other movements with periods of a half or a whole day, a month, and a year. These are the tides.

Everyone who has passed a few days at the seashore, on the Atlantic or the Channel coast of France, has had occasion to note that the level of the sea rises and falls alternately, twice in 24 hours and 50 minutes, that is to say, during the time which elapses between two passages of the moon over the meridian of the place. The phenomenon is, therefore, generally speaking, essentially lunar.

In its details, however, it is easy to prove that it is also solar, for at the syzygies, that is to say, when the earth, the moon, and the sun are in a straight line, the tides are greater than they are at the quadratures, when the moon is in the first or third quarter. The tides also have a maximum at the epoch of the equinox and this proves, beyond question, that they are subject to solar influence.

Newton was the first to give a rational explanation of this phenomenon, an explanation deduced from his law of universal gravitation, and indicated graphically in Fig. 5.

The moon, in consequence of its proximity to the earth, is the principal agent in the formation of tides. It attracts the ocean waters, and changes the form of their surface from a sphere to an ellipsoid, whose apex points toward the attracting satellite. The center of the earth, attracted more strongly than the point directly opposite the moon, gains upon this point, which thus becomes the summit of a second prominence, symmetrical with the first.

If the sun is the prolongation of the line of the earth and moon, as is the case at the syzygies, the effects of the sun and moon are added, producing a "spring tide." At the quadratures, on the contrary, these effects are opposed to each other and the result is a neap tide (Fig. 6).

This explanation, alone, will not suffice to account for all the peculiarities of the tide.

In the first place, if we compute the effect upon the oceanic mass we obtain for the maximum high tide an elevation of only two feet above the mean level of the sea. This is contrary to experience, for the tide rises 50 feet in Mont St. Michel Bay and 70 feet in the Bay of Fundy, Nova Scotia.

Furthermore, according to this theory, the strongest tides should be developed at the equator where, on the contrary, there are many places where the tide rises only from three to five feet.

Finally, at the epoch of the syzygies, the maximum tide should coincide with the passage of the sun and moon over the meridian, instead of occurring as it does much later. In France, this retardation, which is called the age of the tide, is thirty-six hours.

The application of Newton's law, alone, would not enable the tides to be calculated in advance, important though a knowledge of them is to navigators. For the last hundred years, therefore, the British Admiralty and the United States Navy Department have proceeded by a totally different and entirely empirical method.

Whatever may be the complexity of the phenomena which intervene in the production of the tides, it is incontestable that the *determining* causes are the attractions of the moon and the sun and that the *auxiliary* causes are the configurations of the shores and bed of the ocean—that is, the geographical conditions. These conditions may be regarded as constant for a given place for a period of several centuries.

Now, astronomers have demonstrated that the earth, moon, and sun return to the same relative positions every nineteen years. Every nineteen years, therefore, as the determining causes have returned to their former values while the auxiliary causes have remained unchanged, the tides should be reproduced exactly as before.

It suffices, then, to observe the tide *daily* for nineteen years at any port, to obtain the periodic law which will govern the sucessive daily tides of subsequent nineteen-year periods. This method is essentially experimental and entirely independent of theories and hypotheses.

Meanwhile the mathematicians, in the first rank of whom the illustrious Laplace may be mentioned, have persisted in treating the subject of the tides by mathematical analysis.

Laplace, instead of investigating directly the elevation of the ocean's surface produced by attraction, studied the movement of the *tidal wave* which is caused by the action of this periodic force, and which is, consequently, a periodic motion.

Besides, he applied the principle known as the superposition of small motions.*

The subsequent course of the analytical study of the tides is easy to comprehend.

If a disturbing body, like the moon, should move with uniform velocity around the earth, at a constant distance, in the plane of the equator, its attraction would give rise, in consequence of its relative diurnal motion, to periodic disturbing forces whose period would be exactly half a day; and, in any given place, the variations in the level of the sea would always have this semi-diurnal periodicity.

But the motions of the disturbing bodies do not have this ideal simplicity. In the first place, their orbits are inclined to the equator, a fact which at once alters the conditions of the problem and introduces an inequality which is represented, in mathematical analysis, by the superposition of the *diurnal* periodic movement of the sea on the principal wave, of *semi-diurnal* period.

In addition, the declinations of the sun and moon are continually changing; their distances from the earth vary also, regaining their initial values only after longer or shorter astronomical periods; and, finally, the configuration of the coast may make a great difference in the height of the tide which reaches the shore.

To the illustrious English physicist, Lord Kelvin, belongs the honor of having given practical effect to the ideas emitted by Laplace and of having built the noble monument called "harmonic analysis."

Each of the inequalities mentioned above is replaced by a fictitious satellite, whose mass can be computed from astronomical data or local circumstances. If such a satellite existed alone, it would give rise to a periodic wave which could be expressed algebraically by a function of the same period. In virtue of the principle of the superposition of small motions, it would be necessary to take the sum of all the terms of these periodic expressions, and this would be a formidable task. But the genius of the English physicist has triumphed over this difficulty by inventing a machine which solves the problem *graphically*. This wonderful apparatus is called the tide predicter.

Its principle is as follows: If a vertical cylinder which carries a band of paper rotates with uniform speed, while near it a rod is moved up and down by a pin attached to a wheel which rotates, also with uniform speed, about a horizontal axis, a pencil attached to the rod will trace on the band of paper a curve called a *sinusoid*, which may always be regarded as the expression of a periodic motion.

If, then, we have several periodic motions to combine, we take several rods and wheels, giving to the latter such dimensions and velocities as are proper for the representation of the several motions. In order to combine the motions and obtain a periodic curve which shall express the resultant of all of them, each rod ends in a pulley, and a cord engages with all the pulleys and is kept taut by a weight to which the pencil is attached. When the apparatus is set in motion, the motion of each rod represents, in period, amplitude, and phase, the corresponding quantities for the component tide due to one of the fictitious satellites and the pencil, adding together the individual motions, inscribes on the paper the curve of the resultant, or actual, tide.

In the French hydrographic service this apparatus combines sixteen simple tidal undulations and in four hours it plots all the tides of the coming six months.

* This principle may be expressed as follows: Through the action of a very small disturbing force, a material point acquires a very small velocity which involves a displacement so small that the mathematical expression for the force is a function only of the time and the mean position of the point. If, under these conditions, several similar forces act simultaneously, the general laws of mechanics teach that, at any instant, their effects are mutually independent and, therefore, superposable; and, as these momentary effects exert no influence upon the forces themselves, it follows that the resultant effect will be the sum of the partial effects, each calculated as if the force producing it acted alone.

Such are the most recent advances made in the *local* calculation of tides. The *general* theory of the phenomena is far less advanced.

The English physicist, Whewell, supposed that all tides originated in the great Southern Ocean, where waves, free to circulate around the globe without being checked by continents, attain their maximum development. Here the wave of the tide, he thought, could also develop and propagate itself unchecked.

The defect of this theory is that the *age* of the tide has not been found equal to zero in the Antarctic stations where observations have been made. Besides, the Atlantic, and especially the Pacific, are sufficiently extended in longitude to allow the production and propagation of independent tides. It is not necessary, therefore, to assume that our tides have so remote an origin.

At all events, as M. Hatt, the French hydrographic engineer, who has carried the new theory of the tides to its greatest perfection, has so justly observed, so long as this necessity of a distant origin is not proved we cannot deny, *a priori*, the possible effect of tides originating in neighboring seas.

Evidently, the problem of the tides is not yet solved and its solution will be a formidable task of the mathematicians and physicists of the future.—Translated for Scientific American Supplement from La Science au XX Siècle.

THE BEGINNINGS OF COUNTING.*

By Levi Leonard Conant, Ph.D.

In the mind of civilized man as he exists to-day, the concept of number is one of the most familiar of the concepts of daily life. Number is used with the utmost frequency, beginning at an age so early that all remembrance of its origin is lost in the mists of childhood, and continuing, in constant use, down to the last day of our existence. The notion becomes so familiar, so much a part of daily routine, that, except in the case of those engaged in its special study, all perception of number as a distinctive idea is entirely lost; and we give to it no more actual thought than we do to the retina of the eye, upon which the material things of the world picture themselves. Much less do we stop to consider the beginnings of counting, the first perception, wholly unconscious, of course, that there really is such a thing as number.

But the study of this question is of more than passing interest; and some attempt has been made by the writer to examine the origin and to trace the development of the number idea as it appears in the history of human progress. Both physically and mentally, the life of each human being is, in epitome, the life of the human race as a whole; and a study of the development, throughout recorded time, of the number idea as it is seen in the race, is the best possible preparation for a sympathetic understanding of the growth of that idea in the mind of the individual child.

We have no means of ascertaining definitely whether the cardinal numerals precede the ordinals in point of mental development, or whether the ordinals are the first to be awarded distinct recognition. Logical argument has been advanced in favor of the claims for priority on behalf of each class, but the weight of evidence appears to be decidedly in favor of the cardinals.

The first perception of number enters the human mind the moment the child recognizes the fact that two objects are more than one object, and that the two are distinct from each other. Of any clear perception of number the intellect is still quite unconscious; but the number concept begins here, and the moment increase is recognized as resulting from the association of one object with another object, in distinction from mere enlargement of size, the beginning of counting appears.

Number in itself is a purely abstract idea, but the considerations just adduced show clearly that this fact is one which obtains recognition only at a comparatively late stage of mental development. It is at the outset used only in connection with concrete ideas, which are, from the very nature of things, of the simplest possible character. The thought is directed toward the fact that there are two *sticks*, for example, rather than the fact that there are *two* sticks. The objects themselves, and not the mere number of them, fill up the mind. In this sense, the beginnings of counting belong to a stage of development so elementary that it may fairly be said to belong, not only to the most immature members of the human race, but also to the higher orders of the brute creation. Many animals seem to possess a well-defined idea of the difference between one and two, and also a notion, much less distinct it must be admitted, but still a notion, of the difference between two and three, and three and four.

In this connection the following quotation from Sir John Lubbock deserves the most thoughtful consideration: "A man was anxious to shoot a crow. To deceive this suspicious bird, the plan was hit upon of sending two men to the watchhouse, one of whom passed on, while the other remained; but the crow counted, and kept her distance. The next day three went, and again she perceived that only two retired. In fine, it was necessary to send five or six men to the watchhouse to put her out in her calculation. The crow, thinking that this number of men had passed by, lost no time in returning. From this he inferred that crows could count up to four. Lichtenberg mentions a nightingale which was said to count up to three. Every

* School Science and Mathematics.

day he gave it three meal worms, one at a time. When it had finished one it returned for another, but after the third it knew the feast was over. . . . There is an amusing and suggestive remark in Mr. Galton's 'Narrative of an Explorer in Tropical South Africa.' After describing the Demara's weakness in calculations, he says: Once while I watched a Demara floundering hopelessly in a calculation on one side of me, I observed Dinah, my spaniel, equally embarrassed on the other. She was overlooking half a dozen of her new-born puppies, which had been removed two or three times from her, and her anxiety was excessive, as she tried to find out if they were all present, or if any were still missing. She kept puzzling and running her eyes over them backward and forward, but could not satisfy herself. She evidently had a vague notion of counting, but the figure was too large for her brain. Taking the two as they stood, dog and Demara, the comparison reflected no great honor on the man. According to my bird-nesting recollections, which I have refreshed by more recent experiences, if a nest contains four eggs, one may safely be taken; but if two are removed the bird generally deserts. Here, then, it would seem as if we had some reason for supposing that there is sufficient intelligence to distinguish three from four. An interesting consideration arises with reference to the number of victims allotted to each cell of the solitary wasps. One species of *ammophila* considers one large caterpillar of *noctura segetum* enough; one species of *eumenes* supplies its young with five victims; another ten, fifteen, and even up to twenty-four. The number appears to be constant in each species. How does the insect know when her task is fulfilled? Not by the cell being filled, for if some be removed, she does not replace them. When she has brought her complement she considers her task accomplished, whether the victims are still there or not. How, then, does she know when she has made up the number twenty-four? Perhaps it will be said that each species feels some mysterious and innate tendency to provide a certain number of victims. This would, under no circumstances, be any explanation; but it is not in accordance with the facts. In the genus *eumenes* the males are much smaller than the females. . . . If the egg is male, she supplies five; if female, two victims. Does she count? Certainly this seems very like a commencement of arithmetic."

A careful study of this question of the origin of number can lead to no other logical conclusion except the one which Lubbock has here set forth so clearly; that is, that the number sense as it appears in primitive man is not in any marked degree different from the same perception in the case of the higher animals. With this conclusion many writers do not agree, maintaining that there is, in all cases of apparent animal perception of number, simply a perception of greater or less quantity, and no idea whatever of number. But such arguments are not convincing. In a consideration of this question which has now extended over many years, the writer has never yet had brought to his attention any argument against the possession by the higher animals of a rudimentary number sense which would not apply with equal force to many of the primitive races of mankind, and also to the child which has just reached that stage of mental development which enables him to comprehend the difference between one and two.

In this connection it may be well to illustrate by a few examples, the rudimentary condition of the number sense among primitive peoples; and to show by that means how slight is the difference in this one particular between the intelligence of the savage and the intelligence of the most highly developed of the brute creation. There is no recorded instance of a tribe where the idea of number was wholly absent; but as we descend in the scale of intelligence we find that the ability to comprehend this idea, or, to put the matter differently, we find that the ability to count, diminishes rapidly. A point is finally reached where the ability to count seems to disappear altogether, and the entire numeral system, if so dignified a term may here be used, consists of the two words *one* and *many*, or the three words, *one, two, many*. Going still lower, we find certain tribes, like the Chiquitos of Bolivia, where the only trace of a number word is the equivalent for the word *alone*. Here the vanishing point of the number sense is reached; and here the intelligence of the animal may fairly be said to overlap the intelligence of the human being.

The most rudimentary number scales that have ever been recorded by explorers have been found among the native races of South America and Australia. In South America we may cite as illustrations the Encabellada, whose only numerals are *tey*, 1, *cayapa*, 2; the Mbocobi, with *yña tvak*, 1, *yñoaca*, 2; the Puris with *omi*, 1, *curiri*, 2, *prica* many; and the Botocudos, with *mokenam*, 1, *uruhu*, many. These are taken almost at random and are given merely to show the actual extent of the savages' perception of number. Instance after instance of a similar nature might be given; and the count of South American, Australian, and Tasmanian tribes which yield numeral lists no more extensive than those that have just been instanced, is a very long one.

The mental poverty of a human being who can make no use of number except as it is indicated by the words, *one, many*, or *one, two, many*, is at first not easy to understand. But this is due solely to the fact that number has, from earliest childhood, been one of the most familiar concepts of our daily existence. It is one of the fundamentals of modern civilization, and to it we give no more thought than we do to the fact that we wear clothing. But with the savage it is different. Into his daily life the need for any except the most limited number ideas never enters. He learns to distinguish one from two, and perhaps two from three; and that for him is enough. Anything greater than that is always more or less vague in his mind, and, no matter what the number actually is, it is designated by the same word; *many, heap*, and *plenty* being among the most common terms thus employed.

It is only when this condition of barbarism has been passed, and the next stage reached in the development of the race that counting really begins; and it is most interesting to observe that it is now almost always accompanied by some artificial aid. The difference between one and two is clearly understood by the primitive mind; and, as has already been pointed out, the perception of this difference marks the beginning of the number sense. But an attempt to express with any degree of definiteness the next numbers beyond this limit, three, four, etc., results in instant confusion, and the resort is at once had to counters of some kind for the purpose of aiding the mind in its attempt to grasp this new and larger total. These counters are in the great majority of cases the fingers of one, or perhaps of both hands. They are the natural counters, and so convenient have they proved to be that their use has continued through all the stages of civilization through which the race has passed, and they are to-day the familiar counters of the most highly developed races of the world. Their use has resulted in fastening upon modern arithmetic the universal system of which ten is the base—a fact to be deplored, because ten is as a number base decidedly inferior to twelve. If the human race had been provided with twelve fingers instead of ten, the mathematical work of the world would have been done by means of a duodecimal number system instead of a decimal. But when the number of fingers was made five for each hand, the arithmetic of mankind was fixed forever on a decimal base.

As long as the savage remains content with but two numerals he felt little need of any words with which to express his idea of them; and his terms for one and two can hardly be said to have been pure numerals. Any two objects would be in his mind simply "this" and "that." Indeed, there is reason to believe that, in certain languages, the original meanings of the numerals used to designate one and two were precisely those to be found in the words here mentioned. But when any attempt is made to proceed further, the need of numeral terms is at once felt, and the formation of the numeral nomenclature of the language begins. Now and then a case is met with in which the finger origin, the most common of all origins for numeral words, is seen from the very beginning of the count, where one is expressed by some word for finger, and two by some rude paraphrase for double finger. But usually it is impossible to trace the meaning of the very earliest of the numerals of a language.

From a large number of lists the following have been selected as presenting typical examples of the formation of a number scale. The meanings of the various words render superfluous any attempt at explanation, and show with perfect clearness the working of the primitive mind as he passed from one stage to the next. The first is the number scale of the Zuñi Indians, which is as follows:

1. töpinte = taken to start with,
2. kwilli = put down together with,
3. ha'i = the equally dividing finger,
4. awite = all the fingers all but done with,
5. öpte = the notched off,
6. topalïk'ya = another brought to add to the done with,
7. kwillilik'ya = two brought to and held up with the rest,
8. hailik'ye = three brought to and held up with the rest,
9. tenalik'ya = all but all are held up with the rest,
10. ästem'thila = all the fingers,
11. ästem'thla topayä'thl'tona = all the fingers and another above held,
20. kwillik'yënästem'thlan = two times all the fingers,
100. ässäistem'thlak'ya = the fingers all the fingers, etc.

The other scale is that of the Montagnais tribe of Indians of Northern Canada, whose method of progression was the following:

1. inl'are = the end is bent,
2. nak'e = another is bent,
3. t'are = the middle is bent,
4. dinri = there are no more except this,
5. se-sunla-re = the row on the hand,
6. elkke-t'are = three from each side,
7. { t'a-ye-oyertan = there are still three of them,
   inl'as dinri = on one side there are four of them,
8. elkke dinri = four on each side,
9. inl'a-ye-oyert'an = there is still one more,
10. onernan = finished on each side,
11. onernan inl'are ttcharidhel = one complete and one,
12. onernan nak'e ttcharidhel = one complete and two, etc.

Both of these lists are valuable from the fact that they enable us to follow the origin of the words back to the very beginning of numeration, as well as to trace the successive steps in the formation of the systems. Each shows the unmistakable finger-origin of counting, and also the inevitable tendency toward the selection of ten as a base. And yet this statement, confidently as it is made, requires a certain degree of modification. Counting as he does, the savage, on reaching five, says "one hand," "all the fingers on one hand," or by some equivalent expression signifies that he has completed the number which can be indicated in this manner. At ten he says "both hands," or "one man," and at twenty, having completed the tale of counters which nature has placed at his disposal, he says "hands and feet," "all the fingers and toes," "two times all the fingers," or "one man." Though by no means universal, these names for five, ten, and twenty are exceedingly common in all parts of the world. Also, the words for six, seven, etc., are the equivalents for "hand one," "hand two," or "one on the other hand," "two on the other hand," etc.; and for eleven, twelve, etc., we find "one on the foot," "two on the foot," or "all the fingers and one more," "all the fingers and two more," etc. These numeral terms, and indeed the method as a whole, show at once that, while ten is a natural number base, five is an equally natural number to serve the same purpose, and twenty also is a total which might readily serve as a point for fresh departure. While ten is the number of fingers on both hands, five is the number on one hand; and it is the natural number at which the first pause is made. Five is "one hand," in very many languages, and the progression "hand one, hand two, hand three," etc., shows the natural use of five as the base upon which counting was carried on. But no such system ever proceeded far without relegating five to a subordinate position, and assuming ten or twenty as its principal base. The latter number is certainly too large to form a convenient base, and it is a matter of some surprise that the quinary should in so many cases merge into the vigesimal rather than the decimal system.

The vigesimal system is never found entirely pure. Examination always shows the presence of either the quinary or the decimal system subordinate to it. Among the native races of America the quinary-vigesimal system is one of most frequent occurrence, though sometimes a trace of the decimal is also found. The elaborate Aztec system is the most perfect known example of a vigesimal system, but it contained both the quinary and the decimal scales, subordinate to the vigesimal. A similar statement applies to every other system ever recorded, which is built up with the use of twenty as a base.

For some unexplained reason vigesimal, or more properly, quinary-vigesimal number systems are rare in the Old World. The only modern example of it to be found in Europe is the Basque system. Some of the native tribes of Siberia and of the Caucasus reckon by twenties, but elsewhere it is rare. In America it has been found to be more common among the native races than the decimal mode of counting, and the study of these Indian and Eskimo scales is full of interest. But it is a noteworthy fact that in ancient times this mode of counting was common in many parts of Europe. The Phœnicians, and presumably the Carthaginians, reckoned by twenties, and through contact with them the Celtic nations of Western Europe became familiarized with this method of counting; and abundant traces of it are found in their languages. The Bretons still say "unnek ha trigent," that is "eleven and three twenties," for seventy-one. The French say "quatre vingt" for eighty, and from that point to 100 they count by a pure vigesimal scale, as far as the names of their numbers are concerned. The Welsh, the Erse, the Gaelic, the Manx, and other Celtic races show in their languages similar traces of a former use of the vigesimal base. Traces of a similar nature may also be found among the Teutonic languages, but they are infrequent, and indicate but little. A hundred consisting of 120 and known as the "great hundred," or "long hundred," was formerly in use in England, which was legal for certain articles. That its use was common is attested by the popular old distich:

Five score of men, money, and pins,
Six score of all other things.

The very word "score," and a few happily preserved expressions such as "three score and ten," show that an unconscious flavor of the vigesimal had made its way into the reckoning used by our ancestors. The Danish, and other Teutonic languages, contain words and expressions which indicate that the same was true of others of the peoples of Northern Europe. Here, however, the application seems always to have been to material objects rather than to pure number; and the Teutonic number-systems cannot be said ever to have been vigesimal. But the naturalness of this method of counting is emphasized anew by the fact that it forced its way into the material dealings of races whose systems were otherwise purely decimal, and there gained a permanent foothold.

But, however great the number of examples may be of races that have used or now use the quinary or the vigesimal scale, the fact remains that by far the greatest number of uncivilized peoples perform their reckoning by tens; and that, with a meager list of exceptions, all civilized peoples have done and now do the same. With one single exception, the decimal scale is universal in Europe. It is almost universal in Africa; in Polynesia the same is true; in Asia all the civilized, and the great majority of the uncivilized races, count with the use of this base; in North America it has been found among many of the native races; and in South America it was sometimes used, though the prevailing system was either quinary or quinary-vigesimal. The simple, and undoubtedly the correct explanation of the origin of this system, is the laying aside of a counter or the scoring of a mark, on the completion of each tale of ten on the fingers. This develops into a perfect decimal system, and needs or

the introduction of characters, or symbols, to develop into a written number system like the Roman or the Chinese; or, with the aid of place-value, into the Hindu system, which is that of the modern civilized world. As a number base, ten is preferable to either five or twenty; and no number scale could better serve the purpose of mankind than the decimal, with the single exception of the duodecimal. But the advantage of twelve as a base never becomes apparent until the arithmetic of a people has reached such a degree of development that a change from one system to the other would be attended with difficulties so great as to render it quite impracticable. Civilization is wedded to the decimal arithmetic; and though it may buy and sell by dozens and perform its astronomical calculations by sixties, it will always continue to use the arithmetic of tens in preference to any other. All other methods of computation give way, sooner or later, before the decimal; just as all other systems of weights and measures must ultimately yield and disappear before the metric system.

CLAY PRODUCTS OF THE UNITED STATES DURING 1904.

THE value of the clay products of the United States in 1904, as reported to the United States Geological Survey, amounted to the enormous total of $131,023,248. This was somewhat less than the value of the country's clay products in 1903, which was $131,062,421. A chart which shows, in tabulated form, the quantity and value of the various kinds of clay products has recently been prepared by Mr. Jefferson Middleton, statistician, and may be obtained, free of charge, from the Director of the Geological Survey, Washington, D. C.

Of common brick 8,665,171 thousands, valued at $51,768,558, were produced. This shows that the average price per thousand was $5.97. The quantity of vitrified paving brick produced was 735,489 thousands, worth $7,557,425, or $10.28 a thousand. Front brick to the amount of 434,351 thousands was produced at a value of $5,560,131, or $12.80 a thousand. The value of the fancy or ornamental brick produced was $845,630, of drain-tile $5,348,555, of sewer pipe $9,187,423, of architectural terra cotta $4,107,473, of fireproofing $2,502,603, of hollow building tile or blocks $1,126,498, of tile (not drain) $3,023,428. The fire brick produced amounted to 597,760 thousands, valued at $11,167,972 or $18.68 a thousand. The value of the miscellaneous clay products is given as $3,669,282. Under this head are included adobes, aquarium ornaments, assayers' furnaces, boiler and locomotive tile and tank blocks, brick for chemical purposes, burnt-clay ballast, carboy stoppers, chimney radial brick, pipes, tops, and thimbles, clay furnaces, retorts and settings, conduit work, crucibles, flue linings, foundation blocks, gas logs, glass house supplies, grave and lot markers, hollow chimney blocks, insulators, muffles, oven tiles, paving blocks, runner brick, sleeves and nozzles, rustic stumps, saggers, scorifiers, sewer brick, stone pumps, tunnel blocks, and wall coping.

The total value of all brick and tile produced in the United States in 1904 amounted to $105,864,978, or 80.80 per cent of the value of all the clay products. The value of the pottery was $25,158,270, or 19.20 per cent.

The products are tabulated by States as well as by varieties, so that it is easy to see at a glance wherein lies the strength of each State as a clay producer and what rank it takes as compared with the other States. Ohio stands at the head of the list, the value of its clay products for 1904 having amounted to $25,647,783. Of this, $13,978,485 represented brick and tile, and $11,669,-298 pottery. Pennsylvania comes next with a value of $15,421,981 in brick and tile and $1,399,882 in pottery, making a total of $16,821,863. New Jersey's output is more evenly divided, $7,354,294 being in brick and tile, and $5,949,753 in pottery, making a total of $13,304,047. Illinois ranks fifth with a total output valued at $10,777,447; of this, $9,947,751 represents the value of the brick and tile and $829,696 the value of the pottery.

STROBOSCOPIC OBSERVATIONS OF ALTERNATING CURRENT ARCS.

MESSRS. L. LOMBARDI and G. Melazzo, the former of whom is professor of electrotechnics at the University of Naples, have recently made some very interesting stroboscopic observations upon alternating current arcs and thereby thrown a new light on this important study.

As may doubtless be recalled, the first stroboscopic method that permitted of following the optical phenomena of the alternating current arc by direct vision was devised by Joubert in 1881, but the necessity of changing the position of the eye does not permit of utilizing this method for demonstrations. In 1895, Georges and Fleming, in order to obtain a fixed image of the arc for different phases, modified the position of the stroboscopic disk with respect to the shaft of the alternator, or the position of the stationary part of the machine, or, finally, the phase of the current that supplies the arc.

The methods based upon the use of a stroboscopic disk revolving synchronously with the motor permit, however, of obtaining but a single image of the arc resulting from the succession of a large number of instantaneous images all of which correspond to one particular phase of the period. Nevertheless, if things are so arranged that the disk shall revolve at a velocity slightly less than the synchronous velocity of the variation of the current in the lamp, the images obtained will no longer represent the arc always at the same phase of each period, but in phases each of which will fall behind the preceding by a fraction of a period. Hospitalier was the first to describe an arrangement of this kind, and it is to this that Messrs. Lombardi and Melazzo have had recourse.

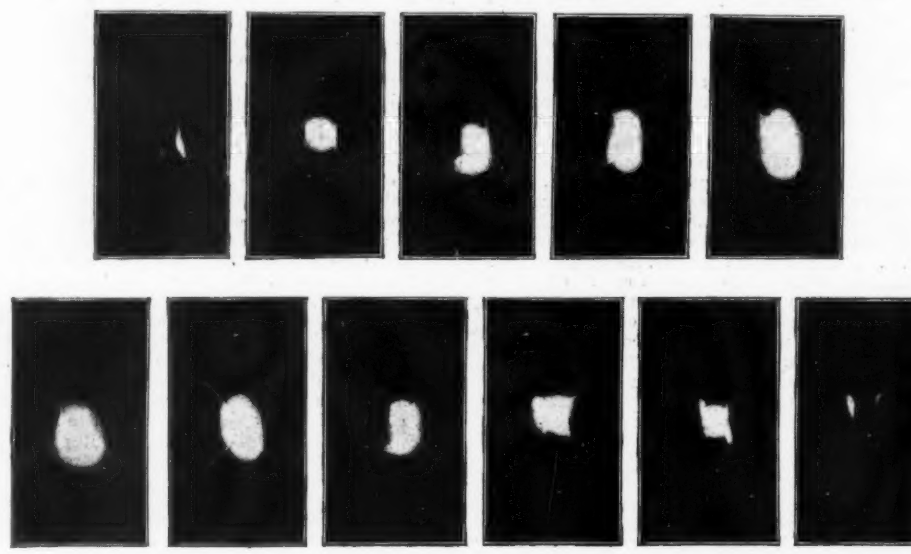
These experimenters started from the principle upon which Dr. Bellini devised a method of measuring the slip of asynchronous motors by counting the variations in the light of the filament of an incandescent lamp supplied by the same alternating current placed in a constant magnetic field. In many of their experiments the stroboscopic disk was mounted upon the shaft of a tetrapolar alternator actuated by the belt of a shunt motor supplied by the continuous current from the electric light mains or from a storage battery. The alternator itself was capable of operating as a synchronous motor upon the same circuit as the lamp, and in this way it was possible to obtain either a non-synchronous speed giving a continuous image of the arc modified periodically, or a synchronous speed, giving a permanent image of the arc for a determinate phase of the period. This phase might, moreover, be modified by changing the position of the disk with respect to the shaft of the alternator. The method seems to be a very advantageous one, as shown by the series of photographs reproducing the luminous images of different alternating or continuous-current arcs between carbon or metal electrodes, the last having been taken at equal intervals of time of one period. In order to obtain a very regular image of a continuous arc as a point of comparison, a Siemens & Halske differential lamp of 10 amperes was employed.

Series I. gives three views of the arc obtained with tensions of 44, 50, and 55 volts respectively. The arc starts from the negative and forms a flame that joins the + crater. Series II. gives 11 different views of an alternating arc between the electrodes of homogeneous carbon of a self-regulating shunt lamp. Series III. shows the arc of the same lamp with wick carbons, and Series IV. the arc of a Ganz lamp of the differential type with yellow light and with carbons saturated and inclined toward the base. Series V. has to do with arcs formed with metallic electrodes. In order to facilitate the comparison, the same time of exposure (a few thousandths of a second) was adopted. The stroboscopic disk made twenty revolutions a second and was provided with two circular apertures 4 centimeters (1.574 inch) in diameter within a circle of about 60 centimeters (23.62 inches) diameter. Although of a low actinic power, the rays of a greater wave length, emitted principally by the flame that surrounded the arc, were filtered through a violet glass screen. The time of development and the strength of the fixing bath were so chosen that the image should be sufficiently sharp in every case.

When the current is very weak, the arc is extinguished; but it becomes relighted when the tension between the electrodes exceeds a definite limit dependent upon the form and nature of the carbons as well as upon the conditions of the electric circuit. With cored and saturated carbons, the arc is formed by a small flame that rises more or less rapidly from the negative crater and reaches the + electrode, while with homogeneous carbons the arc appears all at once in its entire length between the electrodes, and increases in the form of a sphere that rapidly revolves near the extremities of the carbons and quickly disappears at the end of each half-period. It diminishes more quickly than it increases. The arc between homogeneous carbons undergoes greater variations of resistance than that be-

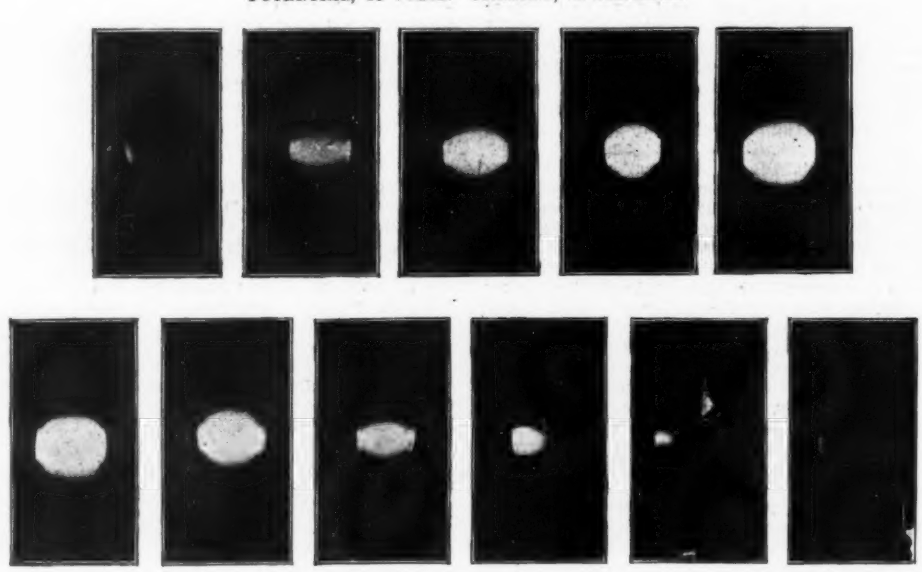
44 volts. 50 volts. 55 volts.

SERIES I.—STROBOSCOPIC OBSERVATIONS OF ALTERNATING CURRENT ARCS.



SERIES II.—STROBOSCOPIC OBSERVATIONS OF ALTERNATING CURRENT ARCS.

POTENTIAL, 44 VOLTS. CURRENT, 11 AMPERES.



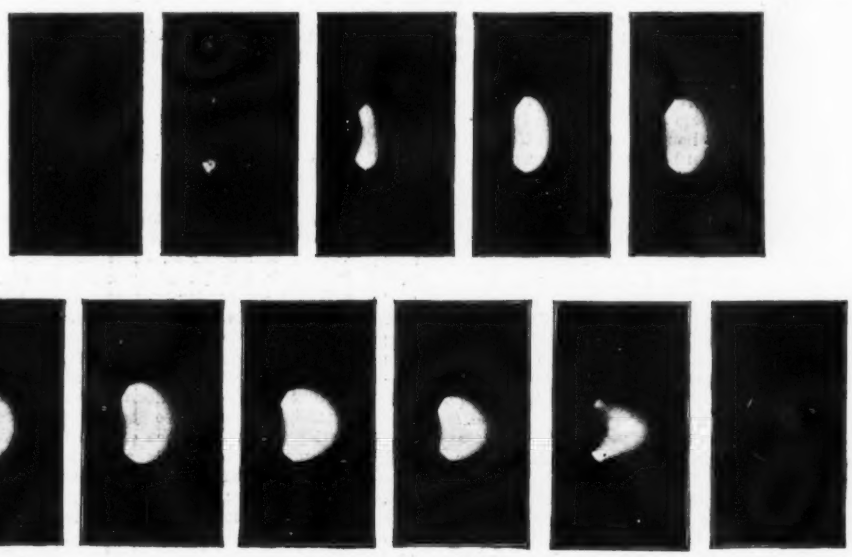
SERIES III.—STROBOSCOPIC OBSERVATIONS OF ALTERNATING CURRENT ARCS.

POTENTIAL, 39 VOLTS. CURRENT, 11 AMPERES.

tween saturated wick carbons. The potential rises to much greater values at the beginning of the period, and the factor of power diminishes at the same time. As the mean value of the factor of power of the lamp with homogeneous carbons, the experimenters have found, 0.63 with wick carbons, and 0.94 with saturated ones. The diameters of the carbons were respectively 12, 13, and 8 millimeters (0.472, 0.511, and 0.334 inch). The intensity of the current in each case was about eleven amperes, and the tensions 44, 37, and 39 volts respectively.

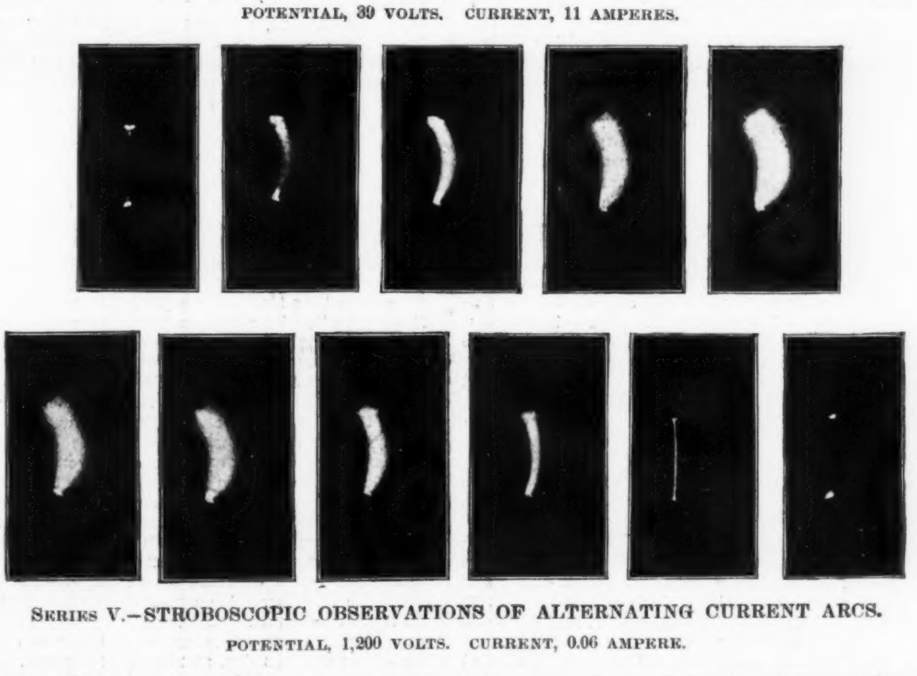
As for metallic electrodes, it was demonstrated as long ago as 1896 that the very high heat conductivity of these and the rapid cooling of their vapor prevents the arc from forming until the tension is exceeds a definite limit sufficient to produce a new disruptive discharge between the electrodes. The peculiar aspect of the arc is clearly seen in Series V., which shows photographs of the arc between two copper electrodes 5 millimeters (0.196 inch) in diameter and 6 millimeters (0.236 inch) apart.

At the beginning of the period there may be seen to jump from the — electrode a very brilliant spark, which requires a very high tension depending upon the frequency of the current, its intensity, and the electric conditions of the external circuit.



SERIES IV.—STROBOSCOPIC OBSERVATIONS OF ALTERNATING CURRENT ARCS.

POTENTIAL, 39 VOLTS. CURRENT, 11 AMPERES.



SERIES V.—STROBOSCOPIC OBSERVATIONS OF ALTERNATING CURRENT ARCS.

POTENTIAL, 1,200 VOLTS. CURRENT, 0.06 AMPERE.

The photographs show a very appreciable difference between the brilliancy of the electrodes. After the phenomenon has begun, we find again the characters of an ordinary arc, which all at once disappear at the end of the period.

The experimenters were enabled also to follow, especially by means of selenium batteries, the remarkable variations of the heat and light emitted in all directions by the carbons of an ordinary alternating current lamp. The stroboscopic method that they employed when using an asynchronous motor, permitted them to demonstrate such variations without any difficulty and in a very instructive manner. In consequence of the great calorific capacity of the electrodes, the heat that they emit varies but very slightly. The variations of light, which are perhaps more important as regards the economy in the distribution, may be perceived directly or may become, through the use of selenium elements, the object of very precise measurements.

It would have been very interesting to study in the same manner the luminous phenomena that occur in the Cooper Hewitt mercury lamp and converter; but the experimenters were unfortunately unable to procure one in order to study the phenomena that take place therein.

SOME NOTES ON NICKEL-IRON AND LEAD STORAGE BATTERIES AND ACCUMULATOR TRACTION.

JUNGNER'S German patents for his alkaline storage battery—which is known in this country as the Edison battery, while abroad it is sometimes called the Jungner-Edison battery—were acquired, as our readers know, by the Kölner accumulatoren Werke Gottfried Hazen in Cologne. The director of this company, Dr. E. Sieg, recently delivered an interesting lecture on the development of this cell by his company, which is published in Elektrotechnische Zeitschrift, March 30. He first discussed in a general way the requirements of automobile batteries.

POWER REQUIRED TO RUN AN ELECTRIC VEHICLE.

The power required for running an automobile is determined by two factors: first, the friction losses of all kinds, together with the efficiency of the gearing devices, etc., and, second, the air resistance. The power for overcoming the friction increases proportionally with load and speed, and amounts to about 80 watt-hours per ton-kilometer on average roads, so that if the automobile voltage is 80, the current consumption in amperes is approximately equal to the weight of the loaded vehicle in (metric) tons, multiplied by the speed in kilometers per hour. This item of power is of decisive importance for all speeds up to 15 kilometers per hour, so that the power for overcoming the air resistance is negligible except on stormy days. For higher speeds, however, the power consumed by the air resistance cannot be neglected, since it increases proportionally to the third power of the difference of the velocities of air and vehicle. For instance, for a light vehicle for two passengers, this item of power, running at 30 kilometers per hour, may amount to one-third of the total power; it depends, of course, greatly on the direction and the pressure of the wind. For practical purposes it is of special importance to know the capacity per unit of weight of the battery, for which the cost of operation is a minimum. The author has made such a calculation, with the aid of calculus under certain simplifying assumptions. He assumes a total weight of 250 kilogrammes of vehicle and passengers; a run of 90 kilometers with one charge; a cost of maintenance of vehicle, excluding the battery, of 0.5 cent per ton-kilometer; and a cost of 5 cents per kilowatt-hour. Under these conditions he finds the following values, y, of the most favorable capacity in watt-hours per kilogramme, corresponding to the values, v, of the speed of the vehicle in kilometers per hour:

v = 10	y = 30.
15	31.2
20	33.3
25	36.
35	37.8

In accordance with these results it has been the endeavor of storage battery manufacturers to increase the capacity per unit of weight, at the expense of life. The company of the author will soon place a lead cell on the market which yields 34 watt-hours per kilogramme. He remarks that this type will not be more expensive per ampere-hour than the heavy types, but will be cheaper. The author thinks that the lead cell has not yet reached the end of its development for automobile purposes, "although even now in every case where the electric automobile may be used (i. e., on roads of at least average quality for speeds not above 30 kilometers per hour and for runs not above 100 kilometers for one charge) it is cheaper than any other vehicle, especially cheaper than a horse-driven carriage."

THEORETICAL POSSIBILITIES OF THE NICKEL-IRON CELL AND TROUBLES EXPERIENCED IN DEVELOPING IT.

The author then gives a long historical review of the development of the alkaline accumulator, and gives some theoretical considerations of the possibilities of the nickel-iron cell. For 1,000 ampere-hours the lead accumulator requires theoretically (according to Faraday's law) 8.4 kilogrammes active mass, the nickel-iron cell 3.4 kilogrammes active mass. However, in the latter case the active mass must be mixed with some conducting material (graphite); this makes 5.9 kilogrammes instead of 3.4 kilogrammes. Moreover, the average voltage of the lead cell is 2, that of the alkaline cell not more than 1.25. Hence 1 kilogramme active mass gives 2.38 watt-hours in the lead cell and 2.11 watt-hours in the alkaline cell. Further, in light lead cells the ratio of active mass to total weight of plates is 70 per cent; in the Edison cell 50 per cent. The author thus arrives at 166.5 watt-hours for the lead cell against 114 watt-hours for the alkaline cell for equal weights. (However, in these figures, the difference in the weights of the electrolyte in both cases is neglected.)

The author then describes the troubles which his company had with developing the Jungner cell after they had bought the patents. These troubles had to do especially with the preparation of the active materials and the construction of the plates. The difficulties encountered seem to have been so great that from the experiments they became convinced that by their method of construction it would be impossible to develop an accumulator equal to the lead cell with respect to lightness and far less one which would be superior. They therefore restricted their endeavors to the development of an accumulator which would be superior to the lead cell with respect to durability in spite of bad treatment. This cell gives only 10 to 12 watt-hours per kilogramme (against 24 watt-hours for the Edison cell). Two modifications of Edison's construction are mentioned: They are sheet nickel instead of nickel-plated sheet steel (since the latter is said to be attacked in time), and they use nickel plates instead of graphite as addition to the active mass.

ELECTROLYTES FOR NICKEL-IRON CELLS.

In L'Eclairage Elec., of April 29, M. U. Schoop and C. Liagre discuss the question of the best electrolyte for a nickel-iron alkaline accumulator. Potassium hydroxide has a maximum conductivity at 29 per cent, sodium hydroxide at 15 per cent, the maximum being greater for KOH than for NaOH. The reasons are given why it is best to use a 20 per cent solution of KOH, as is done by Edison. The authors give some practical rules how to handle alkaline solutions in experimental work in the laboratory. They finally mention the proposal of Michalowsky to use $Al_2O_4K_2$ as electrolyte. In this case it is possible to use zinc, since it is insoluble in this electrolyte. The reaction during charge is given as follows:

$$Al_2O_4K_2 + 2H_2O = 2KOH + Al_2O_3 + 2H + O$$

The two H atoms and the O atom are, of course, not set free, but represent the reduction and oxidation of the two electrodes. The KOH appears at the cathode and Al_2O_3 at the anode. If the electrodes are near enough to each other these two products mix, and $Al_2O_4K_2$ is regenerated. However, the low conductivity of this electrolyte is considered by the authors to be prohibitive for practical use.

THE LATEST LIGHT-WEIGHT FRENCH STORAGE BATTERY.

L'Industrie Electrique of February 10 contains a note on a new lead accumulator called "E. I. t." Both plates are pasted, and it is claimed that the novelty rests in the use of special lead oxides. The useful average electromotive force is stated to be 5 per cent higher than that of the ordinary lead accumulators for the same quantity of active material, and the capacity is said to be 33 to 50 per cent higher than in accumulators in which the ordinary pastes are used. According to tests made in Paris the battery has an energy per weight of 41.2 watt-hours per kilogramme, with an initial electromotive force of 2.29 volts and an initial useful potential difference of 2.07 volts, the discharge being continued down to 1.7 volt at an average rate of 5.5 watts per kilogramme. The density was 1.32 (35

deg. Baumé) at the beginning of the discharge, and 1.16 (20 deg. Baumé) at the end. This unusually high density of the electrolyte might explain the result of the test, and it is very doubtful whether an accumulator with such concentrated acid has any long life. Reference is made to the use of a concentrated solution by Krieger in 1901 on an automobile. He covered 307 kilometers without recharging with an initial electromotive force of 21.5 volts, and with an energy of 38 watt-hours per kilogramme. His sulphuric acid had an initial density of 1.285 (32 deg. Baumé), which is less than that of the electrolyte E. I. t. Nothing was heard later of his battery. To this later note, Krieger replies in the same journal of February 25. He says his battery was not put out of service by this single experiment. He adds, however, that he would not employ every day such a battery. If very great care is taken, he claims, it is possible to get 50 or 60 charges and discharges with such a battery.

The Electrotechn. Zeitsch. of March 2 gives a review of the electrical exhibits in the International Automobile Exposition in Berlin, the author being C. von Groddeck. In reviewing the accumulator automobiles of the Cologne Accumulator Works of Gottfried Hagen, it is said that the older lead accumulators for automobiles of this firm give watt-hours per kilogramme. The weight of an automobile for four passengers is 1,500 kilogrammes, the weight of passengers 400 kilogrammes, and the weight of the battery of 1,700 watt-hours is 850 kilogrammes, hence the total weight 2.75 tons, allowing a single run of 80 kilometers without recharging on the basis of a consumption of 75 watt-hours per ton-kilometers on a level road. The newer lead accumulators of the same firm give 29 watt-hours per kilogramme. For the same automobile as before one gets a single run of 120 kilometers without recharging. On the other hand, if one is satisfied with a single run of 80 kilometers, the total weight of the automobile may be reduced by 350 kilogrammes. With the very latest type of this firm it is said that 34 watt-hours are obtained per kilogramme. The lower weight of the newer types is obtained by the use of a very thin plate which is stated to be protected against buckling by mechanical construction. The increase of capacity is obtained at the expense of life. While the older batteries give 150 discharges before they have to be renewed, the newer ones give only 100 discharges. It is stated, however, that this company has found by experiments extending over several years that this shorter life is not prohibitive, since the increased cost of maintenance of the battery of the newer type is more than counterbalanced by the smaller cost of maintenance of the rubber tires. Some details are given on mechanical construction of automobiles and on benzine dynamo electromobiles. Gottfried Hagen had also exhibited a battery of the Jungner system (competing with the Edison battery in this country); but it is said that the Jungner battery is still in the experimental stage and has not been so far developed that it can be used in practice. The firm states that the batteries are still more expensive than lead accumulators, and that not the same length of run is obtained with them as with lead accumulators. Some electromobiles exhibited by Ziegenberg were equipped with lead-zinc accumulators which "are claimed to give 50 to 70 watt-hours per kilogramme, and to have an unlimited life, while the time of charging is only one-half hour." No further details are given.

For the above notes we are indebted to Electrochemical and Metallurgical Industry.

THE PRODUCTION OF BROMINE IN 1904.

The superior activity of American manufacturers has made for the bromine industry of the United States a place on the European market. The great deposits of haloid salts at Stassfurt and Leopoldshall in Germany are capable of supplying an almost unlimited market, but the American product has nevertheless forced itself into recognition. The result is that German manufacturers have been obliged to offer their goods in America at a price far below that usually current. Hence the price of bromide of potassium has fallen from 25 cents to 15 cents a pound.

American bromine is obtained chiefly from salt brines in Michigan, West Virginia, Ohio, and Pennsylvania. The manufacture of bromine in the United States was begun in 1846 at Freeport, Pa., but subsequently has been carried on chiefly in certain areas of brine production, which are mainly at or near St. Louis, Mich., Pomeroy, Ohio, and Malden, W. Va.

To produce bromine the residual liquids or bitterns from the processes of salt manufacture are treated with sulphuric acid, thus forming hydrobromic acid. From this the bromine is separated by the use of an oxidizing agent which removes the hydrogen. For this purpose either chlorate of potash or binoxide of manganese is used.

Bromine is used by manufacturing chemists, who make from it the bromides of potassium, sodium, and ammonium used for medicinal purposes and as photographic reagents. A small amount of bromine is also used in the preparation of the coal-tar colors known as "eosine" and "Hoffmann's blue." It is employed also as a chemical reagent for precipitating manganese from acetic acid solution, for the conversion of arsenious into arsenic acid, and for detecting nickel in the presence of cobalt in a potassium cyanide solution. Bromine dissolved in water may also be used as a disinfectant. Interesting metallurgical results have been obtained from its use in the bromination and bromocyanide processes of gold extraction, which may, in a measure, become substitutes for chlorination and cyanidation.

The total output of American bromine in twenty-five years has been 10,499,625 pounds, valued approximately at $2,887,917. During 1904 the total output amounted to 897,100 pounds, valued at $269,130. Germany furnishes annually about 300 tons of bromine.

The above facts are taken from a report on the production of bromine in 1904, which Mr. Frederick J. H. Merrill has written for the United States Geological Survey. It is published as an extract from the annual volume "Mineral Resources of the United States, 1904," and may be obtained on application to the Director of the Geological Survey, Washington, D. C.

SOLAR AND TERRESTRIAL CHANGES.

The problem of the relations between sun-spots and other solar phenomena and weather has engaged the attention of men of science for many years past. The results of their investigations have not, perhaps, been so satisfactory or conclusive as were at first anticipated, but this, fortunately, has not diminished the enthusiasm of those interested in the solution of the problem. The ordinary public who were attracted by the apparent simplicity and probability of the relations suggested have undoubtedly been disappointed with the results. There has hence been a tendency for some time past to depreciate investigation in this field of science. On the other hand, the experience of the recent droughts and famines in India, Australia, and South Africa has directed attention strongly to the probable relation between variations of solar activity and the larger variations of rainfall over the earth's surface. The aqueous vapor precipitated as rain over large land areas such as India is produced by evaporation over distant oceanic areas, and is thence carried to the areas of discharge by the larger atmospheric currents. These actions are the direct results of the conversion of solar energy, and any large variation in the supply of that energy must be accompanied with, and followed by corresponding changes in the amount of evaporation and atmospheric movement, and hence, also, of amount and distribution of rain. The determination of the relations thus indicated is not merely of value from the scientific standpoint, but has important practical bearings, as it may lead to a satisfactory method of long-period weather forecasting—a question which is largely engaging the attention of meteorologists at present.

Three lines of observation (and hence also of investigation) carried on at the present time furnish data for the solution of the problem. These are the observations of terrestrial magnetism, of terrestrial atmospheric meteorology, and of solar phenomena.

A large number of magnetic observatories, furnished with the most delicate and sensitive instruments, provide a continuous record of the changes of the earth's magnetic state by its action on magnetized needles at the earth's surface.

The work of meteorological observation has made great progress during the past twenty-five years. It has not only been extended and improved, but is carried on much more systematically than hitherto. Unfortunately its record is very imperfect, as it is probably not too much to say that over at least five-sixths of the earth's surface, including the greater part of the interior of Asia and Africa, and over the larger oceanic areas and the polar regions, the amount of observation is exceedingly small and of little value for the solution of the problem. There is hence a continuous record of the meteorological changes of the earth's atmosphere over barely one-sixth of its surface. There is, moreover, no general collection and publication of the meteorological data in such a form as to give a continuous history of the larger atmospheric variations and changes in progress over even that sixth part of the earth's surface.

The third branch of observation, that of solar phenomena, has made wonderful progress during the past fifty years. Previously the telescopic examination of the sun's surface had disclosed the eleven-year periodicity of the sun-spots. Latterly the combination of the spectroscopic and telescopic observation of the sun has revealed the complexity of the changes in progress throughout the depth of its atmosphere, and of which the sun-spots are only one and a very partial expression. This field of investigation is so promising that solar observatories have been established in many countries, and a continuous record of the solar changes, so far as they are indicated by present methods of observation, is now possible by combining the data furnished by all the observatories. The work of correlating the three classes of observation has, however, not yet been commenced in a systematic manner, although the necessity is now fully recognized.

It is now generally, if not universally, admitted that the sun is practically the sole source of the energy which maintains the movements of the earth's atmosphere. It is the center of a continuous outflow of radiant energy, a very small portion of which is intercepted and appropriated by the earth, where it is converted into other forms of energy. The investigation of the rate of this flow of energy and its time variations, the analysis of the total energy into its elements as that of a series of oscillatory movements of different periods and amplitudes or wavelengths, and the problem of its distribution in its passage through the atmosphere and at the earth's surface are each in little more than the initial stages. In some departments of the investigation, as, for example, the laws of the absorption of the solar energy during its passage through the earth's atmosphere, much work has been done, but with comparatively little result.

The appropriation of solar energy by the earth affects it mainly in two ways, first, as a whole, determining or modifying its magnetic condition, and secondly, partially, affecting the atmosphere and a thin surface layer of the solid or liquid mass. Any variation in the flow of solar energy, periodic or irregular, will theoretically give rise to corresponding changes in the earth's magnetic condition and its atmospheric movements. The determination of the relations between the three classes of variation is on the whole the most important problem in this field of inquiry into the solar energy and its variations and effects.

The first part of the problem, that is, the relation of the variations of solar energy (as manifested and measured by the observable changes in the number and extent of the sun-spots, prominences, etc.) to those of the magnetic condition of the earth shown by its action on the magnetized needle suitably suspended, is comparatively simple, as the earth appears to be similarly affected as a whole and throughout its whole mass. The variations are indicated as clearly and satisfactorily by an observatory in India or Australia as at Kew in England. There are undoubtedly local variations which may require to be eliminated in order to obtain the general variation. It has, however, been conclusively established by observations in different regions that there is a general parallelism between the amount and extent of the magnetic variation or disturbance and the number and magnitude of the sun-spots and prominences. The rule is, the larger the number of sun-spots the greater the amount of the magnetic variation and disturbance. The relation can, however, at the present stage only be considered as statistical, as it has not been established for single sun-spots. In other words, the observed outburst or sudden appearance of a single spot or prominence is not invariably accompanied by a terrestrial magnetic disturbance. Various reasons have been given for the failure of parallelism in detail. Hence all that can be inferred at the present time is that definite relations (of a statistical kind) of great importance have been obtained which more than justify the continuance of this branch of the inquiry, and make it desirable that the work of terrestrial magnetic observation and investigation, and of comparison with solar phenomena, should be maintained and if possible extended.—Nature.

BEGINNING OF THE NEW NORTH POLAR CAP OF MARS.

On May 19, 1905, occurred the first frost this year in the arctic regions of Mars. At the start of my observations on that day I noticed a large and salient white patch to the south and west of the old polar cap. It was so conspicuous as to attract the attention at once and to be instantly recognized as not having been there the day before. For practically the same part of the planet had been under observation then, the disk having been scanned by me from $\lambda = 205$ deg. to $\lambda = 222$ deg. and no subsidiary or outlying snow had been seen. Nor had any been observed there since this part of the disk came round into view on the 11th and the region had been scrutinized every day. It is, therefore, certain that the deposit had taken place some time between the 18th and the 19th of May. The season in the northern hemisphere of Mars was what corresponds to August 20 with us.

The area covered by the new white patch was enormous. It stretched from a little to the east of the old polar cap to a point on the terminator one and a half times the width of the cap distant from that cap's western edge and extended in latitude down nearly to the Helicon. Micrometric measurements of the latitude of its southern extremity gave 61.8 deg. for its position; while measurements of the drawings made the same 63.6 deg. Inasmuch as irradiation would increase the apparent distance from the north edge of the disk while the fact that this edge was a terminator would decrease it, we may approximately offset the one correction against the other and leave the mean of the above unchanged. From simultaneous measurement on the drawings the latitude of the Helicon comes out 58.8 deg. at 205 deg. longitude. In the map of 1903 the mid-latitude of the Helicon I. and II. is just about this value. So that we may conclude the extreme southern end of the fresh deposit to have been 63 deg. of latitude. The axis of the deposit lay in longitude 230 deg. ±.

On the 20th the white patch was again visible and showed a brilliant kernel at its southern end in longitude 70 deg. ±. The deposit, then, had been greatest at a considerable distance from the pole, although extending northward to the confines of the old cap. The relative thinness of the deposit north stood corroborated by the non-obscuration of the band girdling the cap which at moments could be unmistakably traced.

The deposit clearly marked the coming of the first frost in the arctic regions of the planet and from all we know of the physical circumstances betokened a deposit of hoar-frost or snow.

On the 21st the same appearance was re-observed, the position and nuclear character of the new snow being as before, with possibly a slight wane in its brilliancy.

The fall is of interest as marking the beginning of the new North Polar cap. The date at which the fall occurred was $\odot = 149$ deg. or 126 days after the sum-

mer solstice of the northern hemisphere, a date corresponding to August 20 in our calendar.

Such beginning of the new North Polar cap was observed for the first time in 1903 (Bulletin No. 2). The date at which it then took place was 128 or 129 days after the northern solstice. The one observation thus not only confirms the other but presents a striking parallelism of date. On reference to the previous bulletin it will also be noticed that the manner of making of the new cap was the same in the two cases.

June, 1905. PERCIVAL LOWELL.

CONTEMPORARY ELECTRICAL SCIENCE.*

ELECTROLYTIC MANUFACTURE OF FINE WIRES.—H. Abraham has succeeded in preparing very fine and uniform wires by the partial decomposition of a wire in an electrolytic tank. The diameter of the wire is controlled by measuring its resistance, and for this purpose it is attached to metallic rods at both ends. It hangs in the liquid, which does not touch the rods. The solution must be very dilute, and the action slow. The resistance is concentrated in the immediate neighborhood of the wire. The author uses distilled water containing a few thousandths of its weight of copper sulphate for copper wires, or silver nitrate for silver wires. The current employed is about 10 milliamperes per square centimeter of surface of the wire. It must be reduced as the wire becomes thinner. This current intensity allows time for the products of electrolysis to diffuse through the electrolyte. The resistance then keeps highest at the thinnest portions of the wire, and thus regulates the process of solution. The breaking stress of the wire is inversely proportional to its resistance.—H. Abraham, Comptes Rendus, May 29, 1905.

DISCHARGE OF ELECTRONS BY GLOWING OXIDES.—A. Wehnelt communicates some of his results on the emission of electrons by Nernst filaments. The metallic oxides to be investigated were in each case supported by carefully cleaned platinum wires of the same length and thickness, which were in turn fixed along the axis of a hollow brass cylinder. The wire was heated by an alternating current from a small transformer, and could be raised to any desired potential by connecting it to one pole of a high-voltage battery whose other pole was earthed. The cylinder was connected to earth by a galvanometer. A large number of oxides were examined, and it was quickly seen that lime, baryta, and strontia stood out from the rest by their great discharging power, the iron group and the heavy metals having, on the contrary, a very small discharging power. Most likely the oxides reduce the energy required to liberate the electrons. In that respect they should be useful for cathodes. The author found, as a matter of fact, that the cathode drop at platinum cathodes was greatly reduced by coating them with baryta. This renders it possible to work fairly long tubes by means of electric light circuits. These tubes are very effective "valves," as the passage of the current in the reverse direction would require several thousand volts. Hence they can be used as rectifiers.—A. Wehnelt, Philosophical Magazine, July, 1905.

RADIATION OF PLATINUM.—R. Lucas has discovered a simple relation between the temperature of a glowing body and its corresponding "black temperature"—i. e., the temperature at which a perfectly black body would be equally bright. Since the black body has the greatest possible brightness for a given temperature, the "black temperatures" of all other bodies are lower than their actual temperatures. The relation discovered by the author is the following: At equal luminosities, the reciprocal of the actual temperature is a linear function of the reciprocal of the "black temperature." Thus the actual temperature, the "black temperature" as observed, and the same as calculated were as follows, to quote a few figures from the tables:

954	914	915.1
1,422	1,327	1,328.1
1,846	1,691	1,687.9

Another result is that the constant governing the relation between brightness and temperature is nearly the same for the black body and platinum. This means that in the visible spectrum, the radiation, though different in amount, depends in the same manner upon the temperature.—R. Lucas, Physikalische Zeitschrift, July 1, 1905.

MEASUREMENT OF HERTZIAN WAVES.—V. Buscemi has measured the transparency of various substances for Hertzian waves by means of a detector based on the magnetic principle adopted by Fleming. About a core of soft iron wires 13 centimeters long he wound a layer of paraffined cardboard and then a layer of insulated copper wire 0.2 millimeter thick. Then came another layer of cardboard and then another layer of wire 0.47 millimeter thick. The inner coil magnetizes the core, and any wave passing through the outer coil demagnetizes it. The author constructed fourteen of these small coils, joining the magnetizing coils in series and the demagnetizing coils in parallel. He thus was enabled to obtain a current due to the diminution of the residual magnetism of the iron cores. The secondary winding consists of 7,000 turns with a total resistance of 9,900 ohms. The author designed a special commutator which enabled him to insert the magnetizing current at a given moment while the induced currents due to it were excluded from the galvanometer. The next moment the magnetizing current was interrupted, and at the same time the electric waves arrived and demagnetized the iron. The induced currents due to this demagnetization were received in a very sensitive galvanometer. The measurements showed that vaseline oil was practically transparent for Hertzian waves. Next came petroleum, benzine, ether and distilled water, and lastly the acids.—V. Buscemi, Nuovo Cimento, February, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ELECTRICAL NOTES.

In the high temperature produced in the electric furnace it has been shown that all substances can be melted. The oft-encountered statement that lime, magnesia, molybdenum, tungsten, and the like, are infusible is therefore incorrect, for not only can all known substances be melted, but they can be volatilized as well. These facts are full of significance and suggestion to the engineer. They not only show him that there are limitations upon the materials which he may use for furnace construction, introducing difficulties where the highest temperatures are to be developed, but it is possible that in the melting and fusion of materials they may undergo such transformation of their physical nature as to endow them with qualities of great value. One of the most successful industrial uses of the electric furnace is the fusion of aluminium oxide in the form of bauxite, resulting in the production of that physical form of the material designated by the trade name "alundum." This is a duplication of nature's process for producing corundum, but the artificial product has marked advantages over the natural material in the purity, cheapness, strength, and toughness, which give it greater value for abrasive purposes.

In connection with some experiments on wireless telephony made a short time ago by Dr. Mosler, the words spoken into a microphone could be transmitted to a distant telephone if the former were inserted in the primary circuit of an induction coil, one terminal of the secondary coil as well as one terminal of the telephone being connected to earth. Now these phenomena are accounted for by Dr. Mosler on current oscillations analogous to those produced by the microphone, and which, from the secondary terminal connected to earth, would flow into the ground so as to produce a rhythmical electrification of the earth's surface corresponding to language. In an article published in a recent issue of the Elektrotechnische Zeitschrift, Prof. Kalischer suggests another explanation of these phenomena, pointing out that there could be an acoustic transmission of the telephone, even without the action of the earth. In fact, as far back as in 1892, the author observed that the working of an induction coil in a room as much distant from the latter as to exclude any direct observation could be watched by a telephone periodically, provided the arrangement of the secondary coil were not quite symmetrical. If for instance, a piece of wire projecting into the air was inserted into one of the electrodes, a very distant action on the telephone would at once be noted, disappearing as soon as a similar piece of wire was connected to the other electrode. The same was found to be the case on connecting the induction coil to the exciter. As long as the two parts of the latter were arranged symmetrically the telephone would remain silent; if, however, a piece of tinfoil were suspended from one of the wires of the exciter, the telephone was found to emit a sound, this effect being compensated for by suspending from the other wire a similar piece of tinfoil. In connection with the above, the author suggests a simple and sensitive method of determining dielectrical constants by connecting the condenser to be tested to one of the terminals of the secondary coil and compensating it by an air condenser, communicating with the other terminal. If the wire connections be perfectly symmetrical, the telephone will remain silent, as the capacity of the two condensers is identical. This experiment could be readily made in duplicate so as to check the results.

Phosphorus was prepared by Scheele, in 1769, from powdered bones, in which it is present as calcium phosphate. The method he devised for preparing it from this raw material has been in use, with slight modifications, down to the commencement of the present century. The bones were first roasted, and then powdered and heated with sulphuric acid; the solution of calcium hydrogen phosphate obtained in this way was then evaporated to the consistency of thick paste, and heated to a high temperature with powdered charcoal in clay retorts. A mixture of phosphorus vapor and carbon monoxide distilled over, under these conditions, and the former was condensed under water as a yellow, wax-like substance. The crude phosphorus thus obtained requires redistillation. The great difficulty with the old method of production was to obtain retorts which would stand the combined action of the heat and the sulphuric acid, and in most cases the losses due to breakage and to gaseous diffusion through the walls of the retorts were very large. The electric furnace methods of production, on the other hand, dispense with the use of sulphuric acid, and are based upon a reaction which occurs when the bones mixed with sand (silicic acid) and charcoal are heated to a very high temperature in a suitable retort. Under these conditions the silicic acid combines with the calcium to form calcium silicate, and the phosphorus distills over with carbon monoxide gas as before. This method of production was discovered by Wöhler, and has been known for many years, but it could not be used upon an industrial scale until the advent of the electric furnace, since the temperature required to bring about the reaction is much above that attainable with clay retorts and the usual methods of external heating. The phosphorus, in fact, does not commence to distill over until a temperature of 1,150 deg. C. is reached, and the distillation is complete only between 1,400 deg. and 1,500 deg. C. Internal electric heating is necessary to attain this temperature, and in Germany, where already one-third of the output is obtained by the new process, gas-tight iron cylinders, lined with fireclay, and carbon electrodes inside these retorts, are employed for carrying on the manufacture. The process is a continuous one, since the molten calcium silicate can be run off from the bottom electric furnace, since the temperature required to intermittently or continuously at the top. The chief precaution necessary in working this process is to maintain the temperature of the upper part of the furnace and its delivery-pipe above the boiling point of phosphorus (290 deg. C.), as otherwise stoppages of the pipes and explosions may occur.—Technics.

SCIENCE NOTES.

In the Hindu notation of numbers the higher units always precede the lower. This is in accord with the almost universal law, first observed by Hankel, that in the additive combination of numbers the larger precedes the smaller. In numeration we observe the same law except for the nine numbers between ten and twenty. Instead of saying ty-one, ty-two, ty-three, ty-four, ty-five, ty-six, ty-seven, ty-eight, ty-nine, we say eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen respectively. Why should we say thirteen when we do not say three-twenty or three-thirty?

We are ignorant of electrical and magnetic phenomena which depend upon the ether. When the ether is understood we shall be able to understand in a mechanical sense how moving a magnet disturbs every other magnet wherever it may be, why chemical compounds are possible, why crystals assume geometric forms, and why cellular structure in plants and animals can embody what we call life. To discover the nature and mode of operation of this ether is the work of the twentieth century, and we may be sure that he who accomplishes this will deserve to rank with the highest; indeed, it may fairly be said that in importance it is not secondary to anything known, for it is apparently concerned in all phenomena from atoms to masses as big as the sun.

Recently a study of the non-fatty substances which occur in lard and cotton-seed oil was made by Bömer, with the hope of finding a method of detecting adulterations with certainty, and he has developed a very satisfactory and exceedingly delicate process for determining the presence of any vegetable fat in lard. This method depends on the fact long known that there is present in all vegetable fats, but not in pure animal fats, a small amount of a certain alcohol, phytosterol, which has a definite crystalline form, and a definite melting point. These crystals are in general described as "needle shaped," and at the end form an angle of 108 deg. On the other hand, in animal fats there occurs another alcohol, cholesterol, which has a different melting point and an entirely distinct crystalline form, having the appearance of thin rhombic plates. Mixtures of phytosterol and cholesterol produce crystals entirely different from either one of these, being telescopic in shape and easily recognized under the microscope.

To what lengths have the arts of adulteration gone? It is a matter of which the medical profession of this country may be proud, namely, that as a unit they stand committed to the cause of pure food, to opposition to fake advertising, to the restoration of honesty in the trade in food products, and to the elimination from foods of drugs which are useful only in cases of disease. The great army of dentists also in this country stand in the same rank. They are aware, in fact, that if the functions of an organ are suspended the organ itself sooner or later suffers atrophy, loses its power of functional activity, becomes abortive in the course of ages and rudimentary. Thus the great professions of medicine and dentistry in the future will stand together to fight the evils of predigested and prechewed foods. Predigested food will cause the stomach to shrivel and become finally only a rudimentary organ. Prechewed food will in the course of ages produce a toothless race.

Two products are obtained from castor beans by the process of manufacture. The most valuable one, the primary object of the industry, is obviously oil; the other is a residual product, which is in reality an oil cake, but is commercially known as castor pomace. This latter product belongs to that class of oil cakes, including mustard-oil cakes, etc., which have no value as a cattle food, but are used only as fertilizers. In fact, castor pomace, retaining as it does the whole of the poisonous properties of the castor beans from which it is derived, is fatal to live stock. But, containing both potash and phosphoric acid, and being especially rich in nitrogen, it is well adapted to manurial uses. The high percentage of oil it contains prevents its rapid decomposition in the soil, and thus prolongs its fertilizing effects. In some sections of the United States castor pomace is highly regarded as a fertilizer for tobacco and hops. In British India, where more of this by-product is made and used than in any other country, it is much esteemed as a manure for potatoes, wheat, oats, and corn. In the United States, however, the bulk of the output is sold direct to fertilizer factories, and thus enters into general fertilizing uses. The trade in this product is almost entirely domestic, little being exported and none imported.

TRADE NOTES AND RECIPES.

Cement for Chemical Apparatus.—The Drogistische Rundschau recommends this formula: Melt together 20 parts of gutta percha, 10 parts of yellow wax, and 30 parts of shellac.

Coating for Harness.—Melt together 2 parts of mutton suet and 6 parts of beeswax. Add 6 parts of fine, powdered sugar, 2 parts of soft soap, and 2½ parts of lamp-black (harness being oftenest black), and half a part of indigo in fine powder. Mingle carefully and then add 4 parts of turpentine before boxing it.—Nouvelles Scientifiques.

Depilatory Powder.—The following formula is given with some reserve, for preparations of this kind are usually unsafe unless used with great care. Triturate thoroughly until a fine powder is produced, 10 parts of barium sulphide, 5 parts of zinc oxide, and the same quantity of wheat starch. When the powder is to be used, make a thick magma, spread and leave where wanted for ten minutes.—Kosmos.

Product for Cleaning Copper, Nickel, and other Metals.—The composition is in principle the following: Wool grease, 46 kilogrammes; fire-clay, 30 kilogrammes; paraffine, 5 kilogrammes; Canova wax, 5 kilogrammes; cocoanut oil, 10 kilogrammes; oil of mirbane, 1 kilogramme. After mixing these different ingredients, which constitute a paste, this is molded in order to give a cylindrical form, and introduced into a case so that it can be used like a stick of cosmetic.—Revue des Produits Chimiques.

Preservative Paint.—This composition renders good service for stone, wood, cement, etc., especially when the deleterious effects of a moist atmosphere are to be counteracted. It is composed of quicklime, chalk, mineral colors, turpentine, galipot, resin, benzine, and boiled linseed oil. The lime, chalk, and colors are mixed with the turpentine, then a paste is formed by incorporating the linseed oil. This is ground finely, and the resins, dissolved previously in benzine, are added. This is a private preparation, and the proportions of the different ingredients have not been made public.—Science Pratique.

Soldering for Steel.—This recipe, according to the Werkmeister Zeitung, is useful for cases when the steel is not to be soldered at an elevation of temperature to the bright red. Dissolve scraps of cast steel in as small a quantity as possible of nitric acid, add finely pulverized borax and stir vigorously until a fluid paste is formed, then dilute by means of sal ammoniac and put in a bottle. When soldering is to be done, apply a thin layer of the solution to the two parts to be soldered, and when these have been carried to ordinary redness, and the mass is consequently plastic, beat lightly on the anvil with a flat hammer.

Antiseptic Soap Designed as an Antiparasitic Agent.—95 parts of soap are prepared as usual, and 2½ parts of pitch of the black pine are added, taking care that the materials are thoroughly mixed. Then the paste is allowed to cool slowly to 25 or 26 deg. C., and at this temperature 2½ parts of cresol are added, shaking smartly. It is necessary to see that the union of the cresol with the soapy paste is produced as rapidly as possible and inclosed in hermetically sealed boxes, in order that the cresol may not evaporate. The soap thus prepared has not only an antiseptic action, but is destructive to parasites, killing them completely, instead of benumbing them, like many other soaps. Of course, the different constituents can be mingled otherwise, as desired.—Revue des Produits Chimiques.

Fireproof Application for Textile Fabrics and Other Substances.—As a sample of the Melunay process, introduced in France, the following has been published: Apply to a cotton fabric like flannelette, or other cotton goods, a solution of stannate of soda (or a salt chemically equivalent) of the strength of 5 to 10 deg. Baumé, then dry the fabric and saturate it again, this time with a solution of a titanium salt; any soluble titanium salt is suitable. This salt should be so concentrated that each liter may contain about 62 grammes of titanium oxide. The fabrics are again dried, and the titanium is ultimately fixed by means of a suitable alkaline bath. It is advantageous to employ for this purpose a solution of silicate of soda of about 14 deg. Baumé, but a mixed bath, composed of tungstate of soda and ammonium chloride may be employed. The objects are afterward washed, dried, and finished as necessary for trade. A variation consists in treating the objects in a mixed bath containing titanium, tungsten, and a suitable solvent.

New Artificial Wax.—This is obtained by mixing the following substances, in approximately the proportions stated: Paraffine, 45 kilogrammes; white Japan vegetable wax, 30 kilogrammes; resins, or colophonies, 10 kilogrammes; white pitch, 10 kilogrammes; tallow, 5 kilogrammes; ceresine, colorant, 0.030; wax perfume, 0.100 kilogramme. If desired, the paraffine can be replaced with ozokerite, or by a mixture of vaseline and ozokerite, for the purpose of varying the fusing temperature, or rendering it more advantageous for the various applications designed. The following is the method of preparation, according to M. Porchère, patentee: Melt on the boiling water bath, shaking constantly, the paraffine, the Japan wax, the resins, the pitch, and the tallow. When the fusion is complete, add the colorant and the perfume. When these products are perfectly mingled, stop the fire, allow the mixture to cool, and run it into suitable molds. The wax thus obtained may be employed specially for encaustics for furniture and floors, or for purposes where varnish is employed.

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